THE

POPULAR SCIENCE MONTHLY.

FEBRUARY, 1885.

THE SIGHT AND HEARING OF RAILWAY EMPLOYÉS.*

By WILLIAM THOMSON, M. D.,
PROFESSOR OF OPHTHALMOLOGY, JEFFERSON MEDICAL COLLEGE.

SHORTLY after the demonstrations of Professor Holmgren, in Sweden, of the dangers in transportation to persons and property on land and sea from color-blindness, the writer called the attention of the officers of the Pennsylvania Railroad to the subject; and, at the request of the president, Mr. Thomas A. Scott, and the vice-president, Mr. Frank Thomson, he undertook to solve the problem of eliminating these dangerous men from their service. To his first statement that there were probably four per cent of men incapable of distinguishing unerringly between red and green flags by day, or lights by night, it was responded that their signals alone would detect such men, and force them from their places, since, as we all know, the most imperative orders in railway administration are transmitted through the visual organs, in the white of "Safety," the green of "Caution," and the red of "Danger"; and it was considered by the officers of the road impossible for men color-blind to pass the thousands of signals in daily use on their thousands of miles of road without detection. A very slight search dispelled this idea, and a demonstration of the defect before the Society of Transportation Officers of the Pennsylvania Railway aroused the members of it to the dangers to be feared, and led to the appointment of a special committee to aid the writer in completing a system which would have practical value, with the Gen-

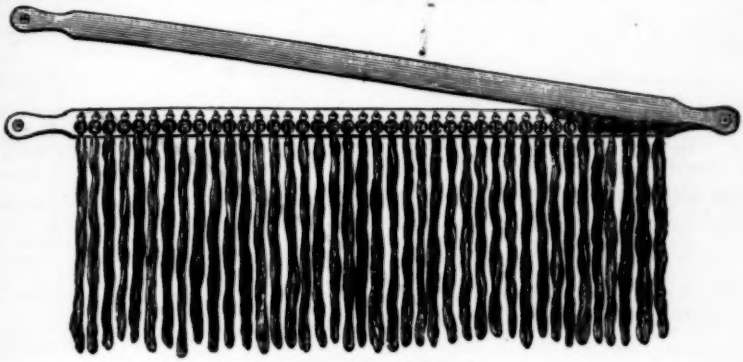
* Read before Section B of the American Association for the Advancement of Science, at Philadelphia, September 8, 1884.

eral Manager, Mr. Pugh, as its chairman, to whose keen interest much of its success is now due.

The magnitude of the task then began to appear, when the forty or fifty thousand employés of five thousand miles of track, with their ten or twelve thousand men actually dependent upon signals of color for their guidance, of whom four per cent might be color-blind, and ten per cent so defective in visual power, for form and hearing, as to render them dangerous, arose before the imagination. To have adopted the method of Holmgren for the color-sense, by which an accomplished ophthalmic surgeon would conduct the examination of each man, would have demanded years of his entire time, would have been so tardy as to allow large additions to the force before it could be accomplished, and was soon rejected as impracticable; neither was it thought possible to train a sufficient number of the company's surgeons to perform this special task with fairness to the men and safety to the company. To secure the co-operation of the employés the officers needed a system that could be applied locally on each division, quietly and confidentially, and at the convenience of the men, without compelling them to lose much time. Any undue publicity, or inexorable law that would compel the summary discharge of from ten to fifteen per cent of their trained operatives, would have disorganized the service, and destroyed the discipline of the company; and for their own protection, and as a duty to the public, the officers were willing to put on trial any practicable scheme, without the pressure of any over-anxious public opinion or hostile legislation.

These, and other considerations of weight, led the writer to the invention of an instrument for the examination of the color-sense, which could be efficiently used by any intelligent, instructed official, and a record of it permanently kept for the information of the officers, and as a guide for the action of any surgical expert whom the road might appoint to superintend the entire system. This consists of forty skeins of wool, each one attached to a movable button, having figures from 1 to 40 inscribed on them, suspended from two flat sticks, so arranged that the numbers are concealed. Holmgren's method of matching colors is adhered to, and the test-colors to be matched are green, rose, and red: the skeins from 1 to 20 being used for green, those from 21 to 30 for rose, and from 31 to 40 for red; upon the *odd* numbers are suspended green, rose, and red skeins; upon the *even* ones those "confusion colors" which the experience of the writer had taught him would be the most likely to be selected by the color-blind. In its use a green skein is placed before the person at a few feet distant, and he is directed to select those of that color from the stick, and to turn them away or throw them over; then the rose, then the red; and as this is done for each test-skein, the numbers upon the buttons are inspected and recorded upon a blank. So simple is this system that the division superintendent, who is responsible for the examination, may forget

all its details if he but remember that upon the blanks submitted to him for his action must appear only *odd* numbers, and that if the *even* ones are mingled the case is one of color-blindness.



DR. THOMSON'S COLOR-TEST.

For the acuteness of vision the best and most simple method is to employ letters of known size at given distances; and, as we might meet with men who could avail themselves of opportunities to learn by heart those of "Snellen," ordinarily used, the writer had a rotary disk constructed on the same principle, whereby but a few letters were exposed to view, but many more could at will be brought into sight when desired. For the hearing, a watch and the voice in conversation were used.

These instruments, together with the Rules and Regulations now submitted to you, won the approval of the committee of railroad officers, were put into practical use in two thousand preliminary examinations, were adopted by the highest officers, accepted by the Board of Directors, and ordered to be put in force upon the entire road, under the supervision of the writer as their surgical expert. His duties were to assure himself of the accuracy of all instruments, to give instructions to the examiners of the different divisions in their use, to give his opinion upon any doubtful cases, their blanks being placed before him, and to examine personally any men sent for the purpose, and to render fit for service, by medical or surgical treatment, or by proper correcting glasses, any capable of such relief.

From an inspection of the blanks, and a knowledge of the men, the Division Superintendent could deal with most of the cases by suspending or transferring them to other duties. The blanks of the color-blind, and those much below the standard of vision, were transmitted to the surgical expert, and, upon his advice, the men could be sent to his office, where the color-blind were re-examined by the "stick" by Holmgren's method, by that of Stilling, advised by the last International Congress, and by Donders's instrument, by which the lights of the lamps and signals at night are so perfectly imitated in color, size,

WEST JERSEY RAILROAD COMPANY.

CAMDEN, *January 19, 1883.*

EXAMINATION OF SIGHT AND HEARING OF

James A. Morris, aged twenty-two, employed as Locomotive Fireman, Applicant for ———.

ACUTENESS OF VISION. The number of the series seen at twenty feet distant.	
Right eye	20–30
Left eye	20–30

RANGE OF VISION.	
Least number of inches at which type D—0,5. in test-type pamphlet can be read.	Right eye, 4½ inches. / Left eye, 4½ inches.
FIELD OF VISION.	
Good or defective	Good.

Color-Sense.

Test-skein submitted	Name given.	NUMBERS SELECTED TO MATCH.
A—Green	Green.	8, 26, 24, 7, 11, 22, 15, 5, 1, 17, 28, 9, 19, 30, 13.
B—Rose	Red.	37, 33, 29, 12, 39, 31, 21, 35, 25, 27, 23.
C—Red	Red.	37, 33, 31, 35, 23.

SECOND COLOR-TEST.			THIRD COLOR-TEST.		
Number shown.	Name given.	Numbers selected.	Flag shown.	Name and use given.	Numbers selected.
24	Green.	26, 22.	Soiled White.	Safety, White.	2, 4, 6.
39	Yellow red.	Could find no match.	Soiled Green.	Caution, Green.	36, 38.
30	Blue.	26.	Soiled Red.	Danger, Red.	37, 33, 31

Selection prompt or hesitating:

Prompt.

Hearing.

RIGHT EAR.		LEFT EAR.	
WATCH.	CONVERSATION.	WATCH.	CONVERSATION.
8 feet.	20 feet.	8 feet.	20 feet.

Remarks:

Escaping steam prevented watch-test.

J. J. BURLEIGH, *Examiner.*

Acuteness, right eye defective. Range, good. Field, good. Color-sense, defective. Hearing, see Remarks.

JOS. CRAWFORD, *Superintendent.*

NOTE.—Those approved marked "Appd."
Those not approved marked "Not appd."

Fac-simile of one of the blanks.

and intensity, and the degree of color-defect measured by means of the ratios that exist between the sizes of the openings transmitting the colored light and the distances at which the man may be placed; the small opening which should be seen by the normal eye at five metres distant, is in diameter one millimetre, while the largest, twenty millimetres, when used at five metres, if not recognized, shows $\frac{1}{20}$ of color-

sense, or at one metre shows $\frac{1}{100}$, or at one third of a metre or one foot shows but $\frac{1}{300}$ of color-sense, where many fail to distinguish the color even at this short distance: finally, by coarse tests of colored glasses placed in front of large gas-lights, and by flags shown near at hand. No color-blind man has lost his place without the satisfaction of a professional examination, and a full demonstration of his defects in most instances even to his own satisfaction. Should he fail to see the red, for example, at five metres, of the large opening in Donders's instrument, or of a gas-light with a red glass before it, calling it green, he would be directed to obey the green signal and approach it slowly, walking up to it until when within one metre or less he might perhaps recognize it as the danger-signal, when too near to prevent an accident. Color-blindness, it must be remembered, is in some respects like deafness, and with its various degrees there are different possibilities of disaster.

No excitement has arisen, no interference with the business of the road, no color-blind man has escaped detection, very few mistakes have been made by the examiners, not a single word has been changed in the instructions, and there is nothing now to amend, except perhaps to make the color-stick into a smaller, more elegant, and self-registering instrument.

One simple test not hitherto mentioned has been used in the first moment of the writer's examinations, by placing a piece of cobalt-blue glass in front of the man's eye, and directing him to look at a gas-light of moderate size like a candle, at twenty feet distance; this glass transmits both blue and crimson light, and the normal eye sees a rose-colored flame surrounded by a blue halo, while the color-blind sees no red, but describes it as composed of two shades of blue only.

That the color-blind depend upon the relative intensity of the lights to distinguish them is shown by the fact that, if over a white light we place a medium shade of London-smoke glass, it will probably be called "green," while a deeper one will be called "red." In like manner, if a red glass, then a green one, are placed before the light alternately, and then tints of red and green of other depths, the man will often call one red, red, and the other red, green, or *vice versa*. In the display of flags that have been in use, a very bright or clean red one having been correctly called, if it be thrown carelessly near by so that it can be compared by the man, and another somewhat soiled be shown, he may pronounce the latter green, and adhere to the opinion even when he takes it in his hand, being misled by the brightness of the cleaner one, and the relative dullness of the other.

This photograph-picture of the color-stick gives in its tints only various ones of gray, since, as we know, colors are incapable of being rendered by this color-blind process, whereas color-blind men have lost but the reds and greens, preserving perfectly the power to see yellows and blues. If, therefore, we were to paint blue that part of the print

between 21 and 30, we who are not color-blind could form a clear conception of its appearance to color-blind persons, and appreciate how impossible it must be for them to conceal their defects under the investigation of the color-stick. Rose, being composed of red and blue in equal quantities, appears as a tint of blue to the red-blind, and green must look to them gray.

It has not been the duty of the writer to investigate cases of accident which might have been caused by defects of sight, but he has been assured by officials that a solution will hereafter be found in them for those hitherto insoluble mysteries where men, otherwise credible, have so flatly contradicted themselves and the circumstances of the case. By one prominent officer he was told that, being upon a train at night, delayed by some slight accident, he himself took a red lantern, and, going a proper distance back, placed himself on the track in the way of an on-coming train, but, finding his light not observed he was compelled to dash it into the cab to attract the engineer's attention, and arrest him in his progress to a collision. Upon the examination of another engineer, his superior officer being present and convinced of his marked color-blindness remarked that, but a short time before, the man had run into the rear of a train properly protected by a red light in the hands of a brakeman some distance in the rear, that the most careful investigation had resulted only in the suspension of the brakeman for not having gone far enough back, but that he was now satisfied that the color-blindness of the engineer had been the real cause of the accident. Some slight or minor accidents recently led to the discovery that another engineer had by some oversight not been tested in his division, and this led to his examination and detection there, and to his conviction by the writer as a color-blind. Still another case now presents itself. An engineer some time ago ran over and killed a brakeman, holding a danger-signal on the track in front of his engine, and no satisfactory explanation could then be given ; but the division examiner predicted that he would probably be found color-blind, and on his examination this proved to be the case.

As a fact it may be safely assumed, in the various emergencies of a railway service, by day and by night, the year round, that, if an accident could occur from such and such contingencies, it will be but a matter of time when it will become a verity.

In a recent popular article on "Control of Vision," Dr. Jeffries, who has done more than any one in this country to call attention to its necessity, laments the entire failure in Connecticut, and the partial failure in Massachusetts, to obtain efficient legislation to compel railroads to expel their deficient men. He tells us of the like condition of things in England ; and finally adds that the Pennsylvania Railway alone has availed itself of scientific advice. Perhaps if the system adopted by it had then been described and urged as most in keeping with our institutions, we might hope to see all the roads in

the country following its example ; but the advice which might be accepted, if proffered in a practicable manner, has been hitherto urged upon the officials by means of hostile newspaper articles, and agitation for legislation to place their entire extra force at the mercy of State-appointed examiners who might disorganize it and bring it into great confusion. There seems to be a natural hesitation on the part of medical men to place the examinations for color-blindness in the hands of laymen, and an equal unwillingness on the part of railroad officials to submit their force to the inspection of a numerous corps of medical examiners, but the solution is found in the use of the instrument described, which merely enables non-professional persons to make a record of certain selections and place them on paper, where they can then be submitted to a surgical expert, who can as well decide upon that evidence as though he were present at the examination, with the understanding that all doubtful cases are to be examined by him in person.

What is gained by this? The expense under the law passed in Massachusetts and Connecticut was estimated to be from two to three dollars per man, to be paid by the roads, and with a penalty of two hundred dollars for the employment of any man not provided with the certificate of an expert appointed by the Governor of the State. For this sum, say three hundred dollars per one hundred men, the road could be informed that from ten to fifteen employés were unfit for its service ; no provision was made for the correction by glasses, or other treatment of the trained men, otherwise so valuable, and no time was allowed to replace men especially fitted for certain duties ; the roads were to be thus taxed for the more than decimation of their entire force, while the employés were subjected to a pitiless scrutiny that would end in the summary dismissal of about fifteen per cent from the discharge of duties for which they had spent, perhaps, years of training. It can easily be understood why such a law would be resisted by all the political or other influences of the entire railway force in a State, from the directors and presidents to the lowest employés, and should awaken also the opposition of the holders of its securities.

By the system adopted on the Pennsylvania Railway, the men below their standard are detected unerringly by their own officials ; those color-blind are sent to the surgical expert, and after his decision are yet retained in the service where possible, being placed where their defects can work no harm. Any valuable men below the standard of visual power can be sent for treatment to their surgical expert, if the officers so decide, or the men can elect to have their defects treated elsewhere, upon the condition that they can pass the proper examination afterward. The one plan, it is evident, is expensive, irritating to the whole *personnel*, and disorganizing, while the other is economical, confidential, and orderly. By a wise liberality in aiding men to have their defects removed by proper glasses, etc., the officers of the road

have been able to carry out their wishes without any noticeable opposition from the employés, and have thus effected for hundreds what would otherwise have cost them thousands of dollars if any plan hitherto proposed had been adopted.

Since only the color-blind and those needing surgical skill have been sent to the expert, he has not been in a position to give statistical tables of the examinations, and he therefore submits the following letter from Mr. Charles E. Pugh, the General Manager, to substantiate his statements, and bear witness to the success of the entire system:

Dr. William Thomson, Surgical Expert, Pennsylvania Railway Company, 1426 Walnut Street, Philadelphia.

PENNSYLVANIA RAILWAY COMPANY, OFFICE OF THE GENERAL MANAGER,
233 SOUTH FOURTH STREET, PHILADELPHIA, PENNSYLVANIA, *April 26, 1884.*

DEAR SIR: The practical examination of our employés as to their acuteness of vision, color-sense, and hearing, in accordance with the system proposed to us by you and carried out under your supervision, has been extended to all the various divisions of the Pennsylvania Railway; has embraced nearly all of the men engaged in duties requiring the use of signals now in the service, and will be used hereafter in the selection of men placed on such duty, or in the employment of new men entering our service.

In approaching the completion of the task of examining those now in our service (more than twelve thousand employés having been submitted to your system), I desire to express to you our entire satisfaction with the rules and regulations, tests and instructions prepared by you, as well as with the personal supervision and instruction of examiners, and examinations and decisions upon doubtful cases and persons referred to you for final action.

Our division superintendents and their staff-officers have been able to deal promptly with the great majority of defective men, and thus avoid the necessity of availing themselves of that clause in the instructions which provides for an expert examination in each suspected case, and have in this way carried out your purpose without undue excitement among the men, in a speedy and confidential way, and with economy to the company.

The proportion of those defective in color-sense, vision, and hearing, was found, by the examination of two thousand men before the adoption of this plan, to be four per cent of the first and about ten per cent of the latter; and I am satisfied from my reports that all those thus deficient are being relieved of duties which they can not perform, and that the great dangers to the public, and to the other employés, of loss of life, and to the company of possible destruction of property, have been averted, so far as their defects are concerned.

I am frequently asked by prominent officers of other railways and Government officials to give an opinion as to the practical usefulness

of our system of examination, and it affords me much pleasure to emphatically commend it in all its details; and I feel that we have good reason to be satisfied with this, the first successful attempt to bring the entire body of men engaged in signaling upon a railway in our country under control by the practical application of scientific facts. Having eliminated these dangerous persons from our present force, we propose to keep it free from them in the future by a steady application of our present system. Yours truly,

CHARLES E. PUGH, *General Manager.*

To this great corporation, extending through six States, operating five thousand miles of track, with nearly if not quite fifty thousand employés, and responsible for the lives of millions of people each year, must be accorded the honor of having been the first to obtain the desired control of the visual defects of their men by a wise and intelligent application of scientific laws. Their example has been extensively followed elsewhere, and their instrument has been obtained by more than thirty other roads from the manufacturers. It has also been ordered by "The Board of Trade of England," by many distinguished medical men abroad, and has recently been, with the entire system, adopted, and will no doubt be put into operation by a director of the Southwestern Railway in England. There is no longer any reason why losses of life and property should occur in railway service from visual defects; and an enlightened public opinion should now insist upon the adoption of some similar plan upon the hundred thousand other miles of railway now being operated in our country.

Having been placed as the American representative on the Committee on Control of Vision at the International Medical Congress in London three years ago, I have urged upon the Naval Committee of our Congress the value of this large experiment, with a view to have a law passed to form an International Commission to establish a uniform system of signals, examinations, etc., both on the land and on the water. There is no doubt that accidents must occur on the sea; and the recent loss of the Tallapoosa has not only been ascribed to a wrong interpretation of the colored signals, but the commission appointed to investigate the accident has been especially directed to examine for color-blindness the lookouts on the two ships.

CALCULATING-MACHINES.

BY M. EDOUARD LUCAS.

WHEN I was a little boy, I sometimes went for the bread to a short distance from the house. The baker would take my tally-stick, put it alongside of his, and cut a notch in both. Then I would go away with my bread and the baker's account on the tally-

stick. At the end of a fortnight or a month the tally-notches were reckoned up and the account was settled. The number of notches represented the number of loaves of bread bought, and this number, multiplied by the price per loaf, gave the amount of money I had to take to the baker.

Although in our present article we shall make use of systems of numeration, and particularly of the decimal system, it is proper to observe that the most important properties of numbers are independent of such systems, and that they are used by the arithmetician in his calculations only for aids, as the chemist uses bottles and retorts. We give two specimens of properties of numbers, which we see illustrated in the problems called the flight of cranes and the square of the cabbages. Cranes in their flight dispose themselves regularly in triangles. We wish to get a rule for finding the number of the birds when we know the number of files; or, supposing that we have arranged the files with increasing numbers from unity to a determined limit, we seek to find the total of the unities contained in the collection. To make the matter plainer, let us seek the sum of the first six numbers, or the number of units represented to the left of the broken line in Fig. 1, by the black pawns. We will represent the same numbers, in an inverse order, by white pawns, to the right of the same line. We shall see at once that each horizontal line contains six units *plus* one; and, since there are six lines, the number of units in the whole square is six times seven. The number we are seeking, then, or the number in the half-square, is half of forty-two, or twenty-one. The same reasoning may be applied

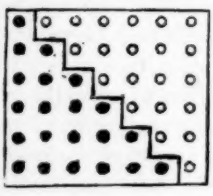


FIG. 1.

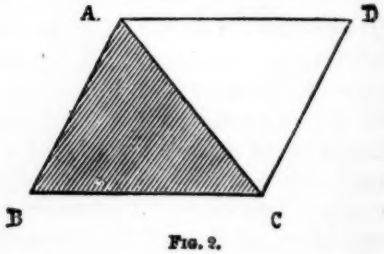


FIG. 2.

to any number; so the sum of the first hundred numbers is half of a hundred times a hundred and one, or 5,050. Therefore, to obtain the sum of all the numbers of any series beginning with unity, all that is necessary is to take half the product of the last number of the series by the next one. An analogue of this mode of reasoning appears in the geometrical demonstration of the proposition that the area of the triangle A B C (Fig. 2) is half that of the parallelogram A B C D, of the same base and height; and reflection will show us that the arithmetical and the geometrical theorems are really one. The numbers we have just learned to calculate, which represent all collections of objects regularly disposed in triangles, are called triangular numbers. The

theory of these numbers was born on the Nile at a remote epoch, and was developed by Diophantes, the father of arithmetic, at the school of Alexandria. In his treatise occurs the proposition, giving, as an essential condition of such a number, that the octuple of a triangular number, augmented by unity, is a perfect square. This fact is made evident by the examination of the diagram (Fig. 3).

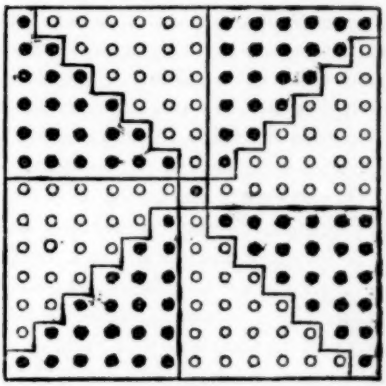


Fig. 3.

An arithmetical progression is a series of numbers in which each member is equal to the preceding member, *plus* a constant number which is denominated the common difference. Thus the odd numbers one, three, five, seven, nine, eleven, form an arithmetical progression, the common difference of which is two. We can demonstrate, as was done in the preceding case, that the sum of the terms in such a procession is equal to the product of the number of terms by the half-sum of the extremes; and, in the same way, the area of a trapeze is half the area of a parallelogram of the same height, the base of which is equal to the sum of the bases of the trapeze (Fig. 4).

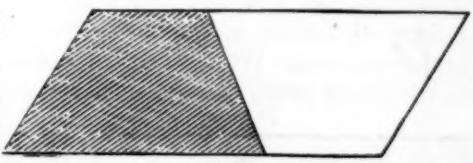


Fig. 4.

Our second example is borrowed from Plato. Fig. 5 represents a square of cabbages. To get the number of cabbages contained in the square, we multiply by itself the number on one of the sides. We have marked lines bounding the successive squares that contain one, two, three, four, five, or six cabbages to the side. Now observe the difference between the numbers of cabbages in one square and the next one. We find that the numbers included in the successive inclosures bordered by our lines are one, three, five, seven, nine, eleven; and we perceive, by reference to the short dotted lines, that the number from one inclosure to another increases by two. We come at once to the propo-

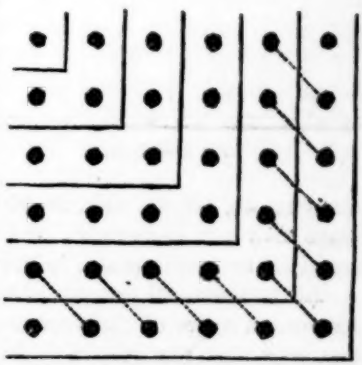


Fig. 5.—The Square of Cabbages.

sition that the sum of the odd numbers, beginning with unity, is the square of their number. Thus, the sum of those numbers between 1 and 199 is a hundred times 100, or 10,000.

Suppose we desire to make a table of the squares of all the numbers up to 1,000, for example, the way that first suggests itself is to make a thousand multiplications, 2×2, 3×3, to 999×999. But this method is of little value; it is exceedingly long, and there is no way of verifying it. We have a surer and more expeditious method. Fig. 6 represents the table for calculating the squares of the first ten numbers. The column D_2, which need not be written, contains 2's; column D_1 represents the series of odd numbers, and may be written off-hand; column Q may be formed after the following law, which applies to all the numbers in the table: *Each number is equal to the one above it in the same column, augmented by the one that follows it in the same line.* Thus, $81=64+17$; and $19=17+2$. A thousand additions of two numbers will then be sufficient to construct our table up to the square of 1,000. But here, it may be said, the results all depend one upon another; any error will carry itself to the next computation, and grow, like a snow-ball that at last becomes an avalanche, and overthrow the whole calculation. The remedy for this inconvenience is easy. When we have got the squares of the first ten numbers, we have only to add two ciphers to have the squares also of the

N.	Q.	D_1.	D_2.
1	1	3	2
2	4	5	2
3	9	7	2
4	16	9	2
5	25	11	2
6	36	13	2
7	49	15	2
8	64	17	2
9	81	19	
10	100		

FIG. 6.—SQUARES.

N.	T.	D_1.	D.
1	1	2	1
2	3	3	1
3	6	4	1
4	10	5	1
5	15	6	1
6	21	7	1
7	28	8	1
8	36	9	1
9	45	10	
10	55		

FIG. 7.—TRIANGULAR NUMBERS.

numbers 20, 30, 40, etc., to 90; we write them immediately in the place they should occupy; and then we must get the same numbers again at the proper places in the course of our operations.

An arithmetical progression of the second order is one in which, if we form a series of the excesses of each number over the preceding one, we obtain numbers in arithmetical progression. Of this order are the series of the squares, and of the triangular numbers (Fig. 7).

There may be also arithmetical progressions of the third and fourth orders, and so on to infinity. They are all calculated in the same manner; and we take for a single example the series of the cubes of whole numbers, which form an arithmetical progression of the third

order (Fig. 8). We get by direct calculation the first four terms, 1, 8, 27, 64; then, by subtraction, the first three terms of the column D_1, the first two of the column D_2, and the first term, 6, of D_3. The table is then completed by the law given above.

N.	C.	D_1.	D_2.	D_3.
1	1	7	12	6
2	8	19	18	6
3	27	37	24	6
4	64	61	30	6
5	125	91	36	6
6	216	127	42	6
7	343	169	48	6
8	512	217	54	
9	729	271		
10	1000			

FIG. 8.—CUBES.

These explanations are necessary to enable the reader to comprehend the function and classification of calculating-machines. The method which is expounded in them appertains to the calculation of differences, and is applicable to all kinds of computations, whether of days' works, tables of interest and annuities, sinking-funds and insurances, tables of logarithms, astronomical tables, or the resolution of numerical equations.

Numeration is based on the theory of geometrical progressions, by which name we call a series of numbers in which each member is equal to the preceding member, multiplied by a fixed number that is called the *ratio*. Thus the numbers 1, 10, 100, 1,000, 10,000 form a progression of which the ratio is ten, or a *decimal* progression. The numbers 1, 2, 4, 8, 16, 32, 64, the ratio of which is 2, form a *binary* progression.

The ancient Tartar hordes communicated with each other by means of sticks notched in an understood manner, so as to indicate the number of men and horses which each camp was expected to furnish. The Inca-Peruvians had knotted cords of various colors, that could be tied in a thousand ways; and the number of knots, their arrangement, the tying of them with sticks, or around a central ring, permitted the expression of a variety of ideas, and of considerable series of numbers. The art of calculation is taught to children in some schools by means of apparatus consisting of a frame with ten rods, on each of which are strung ten counters; and the same kind of an apparatus is managed by the Chinese with much dexterity.

We propose, as an important aid to be used in teaching arithmetical calculation, a vertical checker-board, the squares of which are furnished with pegs on which pawns may be slipped. No distinction is to be made between the white and black squares. We begin by placing ten black pawns in the squares of the lower horizontal row. Lift the pawns in succession from the right, counting one, two, three, up to nine. This

brings us to the top of the column. Take the pawn back to its zero-place, and lift the pawn in the next column, up one place, calling it ten. Then we begin with the right-hand pawn again, two, and count eleven, twelve, etc., to nineteen. Then bring the first pawn back to

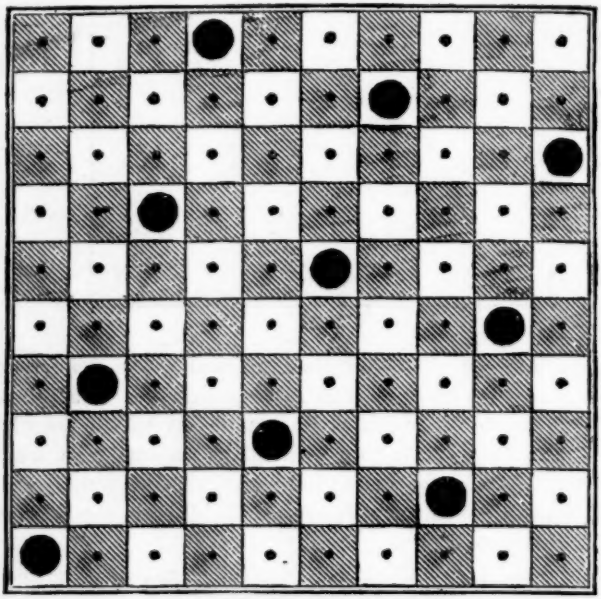


FIG. 9.—THE NEW UNIVERSAL ABACUS.

zero, and, lifting the second pawn to another square, call it twenty, to which we may add the units formed by raising the first pawn, as before. So we may go on with all the pawns, giving each successive piece, as we go to the left, ten times the value of the preceding one.

Our new abacus has the advantages that the value of its places increase in the same direction as the written numbers they represent, while the counters increase in arithmetical value as they are raised higher. As arranged in the cut the board represents the number 0,369,258,147. The capacity of this table, which is now equal to the expression of a thousand millions, may be indefinitely increased by adding columns to the left. The capacity of the board may also be changed by adding to it or subtracting from it in a vertical direction, whereby, instead of counting by tens, hundreds, and thousands, we may count by dozens, grosses, and so on, or by multiples of eight, six, four, two, or any other number. Every system of numeration is thus founded on the employment of units of different orders, each of which contains the preceding one a certain number of times, or, in other words, upon a geometrical progression, the ratio of which is called the base of the system. Aristotle observed that the number four might take the place of ten, and Weigel, in 1687, published a

plan of a quaternary arithmetic. Simon Stevin, of Bruges, had previously devised a system of duodecimal numeration like the one we use in computing time and the degrees of the circle. The almost unanimous choice of the number ten as the basis of numeration was probably suggested by the ten fingers.

Instead of increasing the height of our abacus by two squares to explain the duodecimal system, let us put in its place a rectangle two squares high and of any desired width. We shall then have the system of binary numeration, and be able to write all the numbers with only two figures, 0 and 1. The numbers one, two, three, four, five,

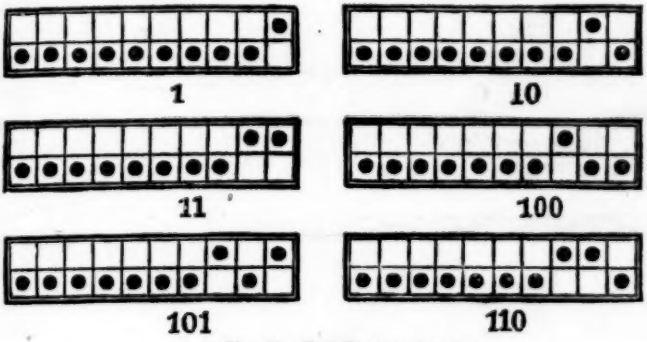


FIG. 10.—THE BINARY ABACUS.

and six, may be formed on this system as in Fig. 10. This system furnishes the explanation of the Chinese symbol "Je-Kim, or Book of Mutations," which is attributed to the venerable Emperor Fo-Hi. It is composed of sixty-four figures, each formed of six horizontal lines written one over the other, some of them whole, others broken in the middle. The whole lines represent units of different degrees, rising from the lowest, and the broken lines zeros.

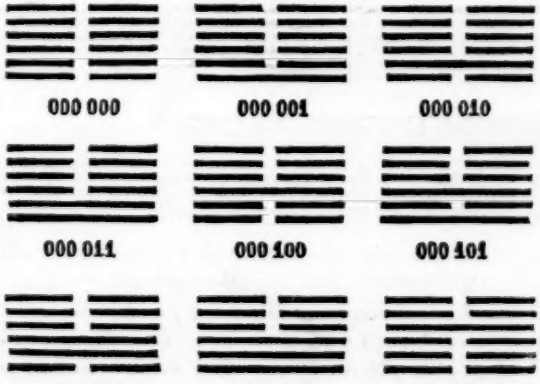


FIG. 11.—THE NINE FIRST CHARACTERS OF THE JE-KIM.

To return to our binary abacus: suppose the first pawn on the right weighs a gramme, the second two, the third four, and so on, doubling to the twelfth, which will weigh 512 grammes; with these twelve weights we can weigh all the whole numbers of grammes to 1023, the sum of all the preceding numbers. The principle is the same, fundamentally, as that of the well-known ring-puzzle. A game was published toward the end of last year, professedly of Indo-Chinese origin, which was called the Tower of Hanoi. The tower was composed of successive stones, decreasing in size as they rose, and represented by pawns, or buttons slipped upon a peg. The game consists in taking the pawns off from the peg and arranging them upon one of two other pegs in such a manner that only one of them shall be removed at a time, and a larger one shall never be put upon a smaller one (Fig. 12). The game is always possible, but demands twice as many removals and twice as much time for each story that is added to the tower. Having learned to rebuild the tower for eight stories by removing it from the first peg to the second one, the problem is made easy enough for one of nine stories; we first remove the eight upper stories to the second peg, then put the ninth story upon the third peg, and rebuild the eight stories upon it. To perform the operation, we must make, for a tower of two stories, at least three removals; for one of three, 7; for one of four, 15; for one of five, 31; for one of six, 63; for one of seven, 127; for one of eight stories, 255 removals. If it takes a second to make one removal, the rebuilding of a tower of eight stories will require four minutes. If the tower consists of sixty-four stories, the readjustment will

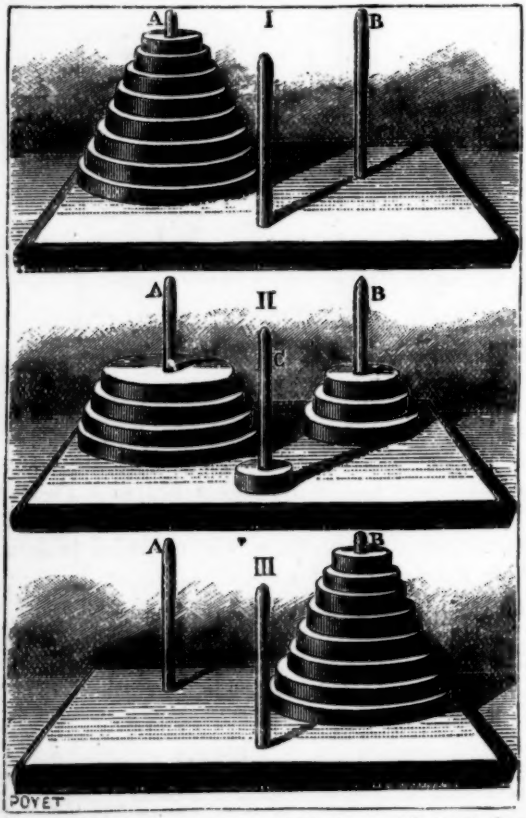


FIG. 12.—THE TOWER OF HANOI. I. The tower at the beginning of the game; II. Illustrating the process of the removal of the stories in the rebuilding of the tower; III. The tower rebuilt.

be a matter of 18,446,744,073,709,551,615 removals, and will occupy five million centuries. This prodigious number comes up again when we calculate the theory of the ring-puzzle of sixty-four rings. According to an ancient Indian legend, the Brahmans took their turns day and night on the steps of the altar in the temple at Benares, to execute the readjustment of the sacred tower of Brahma, of sixty-four stories, of fine gold set with diamonds. When they had done, the tower and the Brahmans would fall together, and then would be the end of the world. The principle of this game corresponds with that which is the basis of the binary system. By increasing the number of pins, and slightly modifying the rules, we can make it represent other systems.

The first machine for executing calculations by mechanical movements was invented by Pascal in 1642. It is illustrated in Diderot's "Encyclopædia," and in some editions of Pascal's works.

Every arithmetical machine is composed of four organs: the generator, the reproducer, the reverser, and the effacer. In Pascal's apparatus and in Roth's most recent modification of it the generator is very rudimentary, being nothing but a rod held in the hand. The reproducer is composed of wheels with ten or twelve cogs, mounted on parallel axes, the first wheel on the right representing units, the second tens, the third hundreds, and so on. Each of the wheels bears one or more sets of figures from 0 to 9, and has in front of it a sheet of metal pierced with an opening through which a single figure can be seen at a time. The mechanism is so adjusted that each wheel after the first one advances by one division or tooth as the wheel to the right of it advances from 0 to 9. Over the circumference of each wheel a notch in the covering-plate allows the generator-rod to be applied to the teeth of the wheel to move it as many numbers as may be desired. We can thus, by successive pushings and readings, perform any additions we wish. Multiplication is performed by successive additions, but the process is slow and tedious, on account of the inefficiency of the generator. The object of the third organ, the reverser, is to change addition into subtraction, and multiplication into division. In Pascal's machine, each of the figure-bearing cylinders of the counter carries two scales, the reverse of each other, on parallel circles, the sum of the corresponding figures on which is always 9; so that the addition of four units of any order on one of the scales effects a subtraction of four units on the other scale. The object of the fourth organ, the effacer, is to bring all the numbers back to zero. In Roth's machine, 9 is made, by turning a button, to appear in the addition scale at all the openings; then the wheel is pushed around by the generator so as to add one, and 0 appears in the place of the 9.

The Thomas arithmometer is a much more perfect and practicable machine. The generating apparatus is composed of a horizontal metallic plate, having parallel grooves, along which are written the figures from 0 to 9. Each groove has corresponding to it a button

with an index, which may be slid in the direction of its length, and by means of which we can enter any number we choose. Each button is connected by a pendent wire, with a ten-toothed pinion, below the tablet. By the side of each of the pinions is a cylinder with a horizontal axis, the length of which is the same with that of the grooving above it. Each of the cylinders bears projecting, upon half the circumference, nine nerves of successively increasing length, from $\frac{1}{10}$ to $\frac{9}{10}$ the length, and the motion of each cylinder is commanded by a horizontal shaft, which is turned by a crank. The cylinders make a revolution with each turn of the crank, but the pinions advance, each only according to the number of teeth marked by the corresponding index. Pinions mounted on the same axis with the index transmit the motion to the figure-bearing wheels of the reproducer, which is placed under a metallic plate, prolonging the first one. Each turn of the crank produces the successive terms of an arithmetical progression. Suppose we wish to multiply 37,456 by 435. We bring down to zero the figures opposite the openings in the reproducer by means of an effacer, which is to be described. We write on the tablet the number 37,456; then turn the crank five times, when we will be able to read through the opening the product of 37,456 by 5; to get the product by 35, we would have to turn 35 times, but for an ingenious disposition by which we push the whole apparatus a notch to the right, and turn three times, which gives the product we are seeking; then pushing another notch to the right, and turning four times, we have the product by 435. The function of the reverser may be best explained by a comparison. Suppose a carriage of two wheels and an axle-tree, and a person is riding upon it holding an opened umbrella. As long as the umbrella is held straight over the middle of the axle, it does not move; incline it over one of the wheels, it begins to revolve; incline it over the other wheel, it will turn in the contrary direction, while the carriage will be all the time going straight ahead. In the arithmometer, the wheels of our carriage are replaced by twin-pinions and the umbrella by the figure-bearing wheel of the reproducer. By pushing on a little lever, we bring whichever pinion we desire into gear with the figure-bearing wheel, so that each turn of the crank—it always turning in the same direction—brings successively before the openings numbers increasing or decreasing in an arithmetical progression, of which the common difference is marked on the abacus of the tablet.

Lastly, the effacer illustrates the advantage that may be drawn from a broken tooth. Below each figure-bearing wheel is found, solid with it, another smaller toothed wheel in which the tooth corresponding with the 0 below the peep-hole is suppressed. A roweled button pushes along a rack, that keeps the wheel turning, till the moment when the 0 is to appear before the opening. The operation is performed with extreme rapidity, and is one among many admirable details in the per-

formance of the machine. With this instrument, which my children learned to use when they were seven years old, the product of two numbers of ten digits can be obtained in half a minute; and it is used in numerous offices and institutions in France, the average sale of it being a hundred a year.

About a half a century ago, Charles Babbage undertook the construction of a universal calculating-machine, which should give the successive terms of arithmetical progressions of different orders; but, having devoted the latter part of his life, and all of his fortune and income to it, died without finishing it. George Scheutz, of Stockholm, and his son, Edward Scheutz, exhibited a machine at the Paris Exposition of 1855, which was bought by a citizen of the United States and presented to the Dudley Observatory in Albany. It is shaped like a small piano, and by simply turning the handle gives out the successive terms of arithmetical progressions, not of the first order only, but of the second, third, and fourth orders.

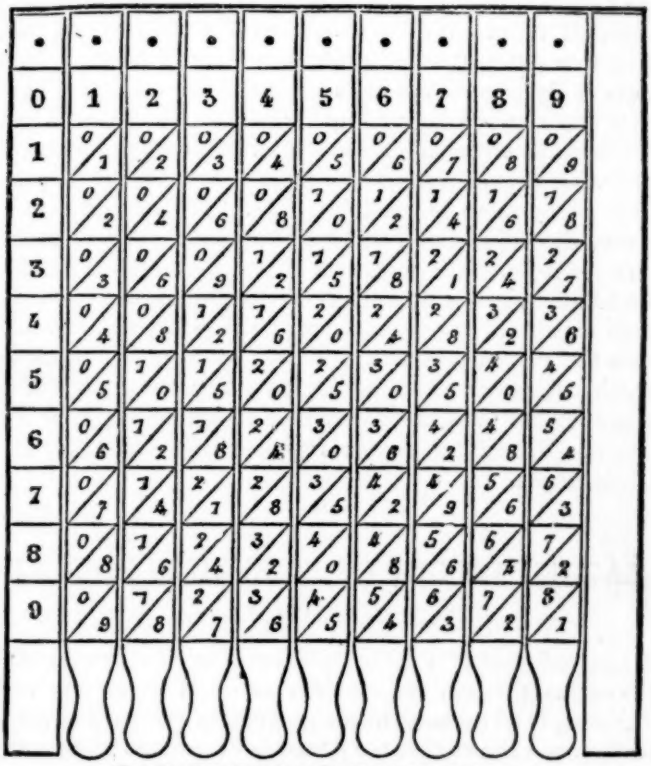


FIG. 13.—THE TABLE OF PYTHAGORAS ON SLATS.

John Napier, the inventor of logarithms, suggested an ingenious method of performing the operations of multiplication and division. The table in Fig. 13 represents the table of Pythagoras dissected into

ten slats, of which the one on the left is fixed, while the others are movable and can be changed about at pleasure. Each of the squares of the table is divided by diagonals into two triangles, in the lower one of which is found the figure of the units of each of the products, and in the upper and left one the figure of the tens. If we place by the side of the fixed bar the slats bearing at the top the numbers 7, 5, and 8, we obtain almost immediately the products of 758 by all the numbers from 1 to 9. Thus, before the 6 of the fixed bar, we find, looking horizontally, 6 | $\frac{4}{2}$ | $\frac{3}{0}$ | $\frac{4}{8}$ | ; and by making the addition parallel to the diagonals, we have 4548 as the product of 758 by 6. The other products are got in the same manner. These slats then permit us to find rapidly—without having to know the table of Pythagoras, but by the simple addition of two figures—all the partial products by a number of ten figures. Thus, multiplication is again brought back to addition. This invention, however, has not become practical, because of the difficulty of finding the products when the multiplicand has two or more similar figures. An invention of our own gives it a more practical form. We have replaced the slats by square rules, containing four different numbers on each of the four faces, by which four tables of Pythagoras are included in the same space. But a little addition is still required for finding each of the partial products. M. Henri Genaille, an engineer of the state railroads, has devised a plan for substituting these additions by simple designs, that will permit all the partial products to be read instantly. The management of the rules is very simple, and may be learned at once. As perfected by us, this apparatus replaces the operations of multiplication and division by a simple addition, or a subtraction. With the boxes of the Genaille rules, each eighteen centimetres long, twelve wide, and one thick, we can obtain the partial products of all the numbers to twenty figures. With another disposition of the rules, on a larger scale, it will be possible to give all the products of numbers of ten figures by other similar numbers.—*Translated for the Popular Science Monthly from the Revue Scientifique.*

THE LARGER IMPORT OF SCIENTIFIC EDUCATION.*

By J. W. POWELL, LL.D.

THE establishment of a School of Science and Arts at the capital of the nation, through the munificence of Washington's venerable philanthropist, is a landmark in the progress of culture and the history of education, and shows that the demands of modern culture are fully recognized. Let us briefly glance at some of the characteristics of this new education.

* From an address delivered at the inauguration of the Corcoran School of Science and Arts, in the Columbian University, Washington, D. C., October 1, 1884.

Scientific education is catholic; it embraces the whole field of human learning. No student can master all knowledge in the short years of his academic life, but a young man of ability and industry may reasonably hope to master the outlines of science, obtain a deep insight into the methods of scientific research, and at the same time secure an initiation into some one of the departments of science, in such a manner that he may fully appreciate the multitude of facts upon which scientific conclusions rest, and be prepared to enter the field of scientific research himself and make additions to the sum of human knowledge. Honest investigation is but the application of common sense to the solution of the unknown. Science does not wait on Genius, but is the companion of Industry. Under the *régime* of the elder education, the larger number of those who prepared themselves to be scholars, by acquiring the languages in which scholarship was embodied, never passed beyond the portal to knowledge, but speedily fell back into the ranks of the unlearned. Only the few went on to explore the fields open before them; *many were called, but few were chosen.* Scientific education takes men at once into the very midst of the new philosophy.

There is no calling in life to which a cultured man may properly aspire in which a scientific training is not essential to success. This can not here be fully set forth, but some illustration may be given. If the scholar would devote himself to law—law itself is now a science, and, in the application of the principles of law to facts as they exist in modern civilization, a general knowledge of the facts which constitute the body of science is essential. In the East some of the greatest lawyers of the land are to-day engaged in gigantic litigation relating to the invention of the telephone, and in the far West other great lawyers are engaged in litigation relating to mines, which involve the facts and principles of geology. On every hand are kindred illustrations.

But there is a line of facts in the history of law which peculiarly illustrates this proposition. In savagery and in barbarism despotism is not highly developed. The greatest despotisms of the world were established in early civilization. In the main these despotisms were established on four fundamental ideas: first, there was property in man; second, tenure to land was feudal; third, the king was the fountain of justice; fourth, facts were established by compurgation. The last is of interest here.

In early civilization there were no proper legal methods by which to determine the facts involved in legal controversy, and, when courts were convened and juries organized, the facts were to be obtained from the averments of the interested parties, and no system of assembling evidence by witnesses, as now known in our courts, then existed. The parties to litigation, civil or criminal, made their statements and substantiated them by compurgators. Every man in an ancient commu-

nity was supposed to have his friends who would vouch for the truth of his statements, and he stood best before the courts whose vouching friends or compurgators were the most influential. No device for the establishment of despotism and wrong has ever been more efficient than the system of compurgation.

In modern legal practice all this has been changed, and the law of evidence has been vastly developed, until it constitutes one of the most important departments of law; and to-day, in the hearing of cases, the larger share of the time is devoted to the establishment of the facts, and the greatest skill of attorneys is exercised in this branch of the case; and every great lawyer and jurist now understands that it is easier to grasp the principles of the law than to reach the facts which should guide in their application. Thus it is that a knowledge of the facts and the principles of science is essential to him who would be successful as advocate or as judge.

Perhaps the student aspires to be an historian. In the past, history has been devoted chiefly to the exploits of heroes and the story of wars; but history is now being speedily reorganized and rewritten upon a scientific basis, to exhibit the growth of culture in all its grand departments. History itself is now a science, and is no longer an art in which men exploit in rhetorical paragraphs.

In many ways and on every hand it can be shown that scientific education furnishes the training that is needed for life in modern civilization.

I refrain from alluding to the relations of such a school to the stupendous industrial accomplishments of modern civilization, and to the training demanded thereby; first, because that field has already been well cultivated; and, second, because it has been lately assumed that scientific education is wholly utilitarian. It is true that all utilitarian training is scientific, but that is not the only characteristic of scientific training—it is catholic, it is universal.

Scientific education gives the highest mental training; scientific education means a training in modern scientific culture. What this culture is, has already been outlined. It is the product of all the mental endeavor of the race to which we belong. This struggle for improvement, this grand endeavor to secure happiness through human activities, which have been defined as the humanities, began in remote antiquity. Where our race lived in savagery, we know not. All we know is that at some time and in some place our ancestors were savages. In Asia and in Europe and in Africa this struggle was continued. Slowly and painfully, with many misfortunes and many reversions, the Aryan race has steadily moved forward in the march of culture, and every branch of the race has contributed its part. Every great artisan and artist, every great statesman, every great linguist, every great philosopher, every great thinker in all that time, has contributed his part; and, more than this, our race has borrowed from

the other races of the world everything which they could contribute worthy of our acceptance.

Modern culture, therefore, stands as the product of all mental endeavor for all time. It may, then, be safely assumed that the study of that which has made civilization, and *is* civilization in its highest form, and which is the result of all the training of all the world, must itself furnish the best subject-matter for training that human ingenuity can devise.

Scientific education is æsthetic training. To purblind ignorance the beauties of the world are dimly seem, but the glory of the universe is revealed by science. Classic poetry was the best literary product of its time, because it was informed by the philosophy of its time. Its philosophy was chiefly mythology, and the characters of ancient poetry are mythic heroes and gods. So the highest literature of the new civilization must be informed by its highest philosophy; it must be instinct with that knowledge of the universe which is now the glory of the scholars of the world. The splendors of the heavens and the earth, as known to modern science, have put in eclipse the dull glories of ancient mythology.

Scientific education is a training in mental integrity. All along the history of culture from savagery to modern civilization men have imagined what ought to be, and then have tried to prove it true. This is the very spirit of metaphysic philosophy. When the imagination is not disciplined by unrelenting facts, it invents falsehood, and, when error has thus been invented, the heavens and the earth are ransacked for its proof. Most of the literature of the past is a vast assemblage of arguments in support of error. In science nothing can be permanently accepted but that which is true, and whatever is accepted as true is challenged again and again. It is an axiom in science that no truth can be so sacred that it may not be questioned. When that which has been accepted as true has the least doubt thrown upon it, scientific men at once re-examine the subject. No opinion is sacred. "It ought to be" is never heard in scientific circles. "It seems to be" and "we think it is" is the modest language of scientific literature.

In science all apparently conflicting facts are marshaled, all doubts are weighed, all sources of error are examined, and the most refined determination is given with the "probable error." A guard is set upon the bias of enthusiasm, the bias of previous statement, and the bias of hoped-for discovery, that they may not lead astray. So, while scientific research is a training in observation and reasoning, it is also a training in integrity.

Scientific training is an education in charity. Sympathy for the suffering of others is at the basis of eleemosynary charity, and it has grown with the development of social interdependence. The charity that was born in the family in primitive times, with the growth of the tribe into the nation, has developed into national charity, and finally,

in modern civilization, it has become the great principle of philanthropy. Now the sufferings of all mankind touch the hearts of all men. If a tornado destroys a village, the whole world tenders alms; if a party of heroes are starving in the ice-fields of the North, their sufferings kindle sympathy in the heart of every civilized man.

But there is a charity unknown to tribal society, and little known in early civilization—a charity born of knowledge, a charity kindled in the hearts of men by science. It is charity for men's opinions—philosophic charity. In all the past, he whose opinions were not in conformity with current beliefs was held to be depraved, and hemlock was his portion, or fagots were used for his purification.

It has at last been discovered that the world has always been full of error, and we are beginning to appreciate how man has struggled through the ages from error to error toward the truth. We now know that false opinions are begotten of ignorance, and in the light of universal truth all men are ignorant, and as the scholar discovers how little of the vast realm of knowledge he has conquered he grows in philosophic charity for others. The history of the world is replete with illustrations to the effect that the greater the ignorance the greater the abomination of unconforming opinion, and the greater the knowledge the greater the charity for dissenting opinions.

EVOLUTION AND THE DESTINY OF MAN.

By W. D. LE SUEUR.

"THE Destiny of Man viewed in the Light of his Origin" is the important and interesting subject to which Professor Fiske devotes the last work that has issued from his pen. It is as true to-day as it was in the days of that Northumbrian king whose reason for hearing the Christian missionaries has so often been cited with approval, that men have a longing to know what may lie beyond the portal of death which closes so solemnly and, as it would seem, mysteriously upon all the activities of life. The Christian religion has been answering the question in its own way for well-nigh nineteen hundred years, and it might not be too much to say that upon that answer, authoritatively given, more than upon anything else, its wonderful and prolonged vitality has depended. What troubles the minds of many to-day is a doubt as to whether there are solid and reasonable grounds for what has so long been taught with authority. Was the tone of certainty assumed by Christian teachers at the outset anything more than a strong persuasion due to the workings of imagination? Does the answer so confidently given, and so devoutly accepted by countless multitudes in past ages, still hold good? Is the soul of man

something altogether apart from his bodily frame? Does it maintain its individuality, its elemental purity, while the body falls asunder? Does it necessarily endure eternally? And is it true that, the coil of earthly life once shaken off, every human soul departs into a condition either of everlasting bliss or of everlasting and unspeakable torment? To all of these questions the Christian religion has answered, and must still answer, "Yes." In what respect, then, it may be asked, does Professor Fiske seek to modify the Christian message; or does he simply state over again, on the authority of Science, what Christianity had affirmed on the authority of supernatural revelation?

In reply to these queries it may be briefly stated that Professor Fiske confines himself to asserting, in the name of Science, and particularly of the doctrine of evolution, the separate and essentially independent existence of the human soul. Whether, such being the case, he can claim to have thrown any light on the *destiny* of man, is perhaps a debatable point. It seems to me that he has rather dealt with the statics of human nature than with the question of the final outcome of human activity. It may be doubted whether, if the Christian missionaries at the court of the Northumbrian king had contented themselves with announcing that man had a soul, and that the soul was imperishable, they would have made much impression on their heathen listeners. Animistic interpretations of the phenomena of human life have been common in all ages—so common that, from their apparent universality, Mr. Spencer deduces the conclusion that all religion is based on primeval ghost-worship. Mr. Fiske comes forward to-day to say, in effect, that animism has the warrant of Science. Well and good! It may have; that all depends upon the interpretation of facts. But establish the point, and we shall at once want to know what are the fortunes of the soul after it leaves the body. Does it repair to happy hunting-grounds? Does it wander in a meadow of asphodel? Does it flit about in eternal twilight? Does it repair to the court of Minos and Rhadamanthus? Does it take on other animal forms and so revolve through a ceaseless round of changes? Or does a judgment await it that will place it irrevocably on one side or the other of the eternal dividing line, the everlasting gulf, which shall separate the saved from the lost? Unless some one will answer these questions for us, it seems almost vain to pretend that any light has been thrown on the "destiny of man" (beyond the present life) by the mere assertion, on whatever grounds, that the "soul" is something essentially distinct from the body.

It may be further affirmed that even the latter statement, when taken by itself, will prove unsatisfactory, unless a clear delimitation is established between what belongs to the soul and what to the body. It is to be feared that there is much the same uncertainty and vagueness in the use of the word "soul," which Matthew Arnold, in his "Literature and Dogma," has signalized in the case of the word "God." Peo-

ple think they know what they mean, and that they all mean the same thing, when they use the word "soul." But do they? If we are to attach importance to the doctrine that the soul is not of the same nature as the body, and exists, or can exist, apart from the body, it is surely above all things necessary that we should hold some orthodox creed as to what the soul is in itself, and what the body is in itself—what, in a word, each is that the other is not. It might have been expected that a writer of the scientific habit of mind of Mr. Fiske would have presented some definition of the word "soul" in the work before us; but I fail to find that he has done so. We are left in this matter entirely to our own more or less vague preconceptions. It would have been satisfactory could we have been informed whether the soul, in parting from the body, carries away with it any elements or influences derived from the body, or whether it simply reverts to the condition in which it existed before its union with the body. Some information of this nature is necessary before we can be sure that our knowledge is much advanced by being told that the soul continues to exist after the body has been dissolved. What, exactly, continues to exist? How much of what we now reckon as ourselves? Then, again, though it might not, strictly speaking, form part of the discussion as to the *destiny* of man, it would seem proper that a scientific expounder of animism should at least hazard some conjecture as to where or what souls are before their union with bodies; whether they exist individually or whether they are but parts of some homogeneous soul-substance,* and only become individualized as the result of their union with individual bodies. Especially might we look for this when the subject discussed is "the destiny of man viewed in the light of his origin." If there be the sharp distinction affirmed between man's soul and his body, we should hardly expect the natural history of his body to throw much light on the destiny of his soul. We should certainly be better prepared to form an opinion or a belief as to the course of the soul after it leaves the body, if we could have some grounds for an opinion or belief as to the mode of its existence before it joined the body. If it be held that it had no previous existence, it may not be evident to all why it should survive that body at a certain point in the development of which it would seem to have had its birth.

These are preliminary considerations. Mr. Fiske has not given us all that might have been expected in a treatise bearing the title he has chosen, and pointing to the conclusions he indicates. Still, he has given us something, and it may repay us to examine what the actual content of his work is. To say that the work is written with grace and charm and skill, is only to say over again that it proceeds from the pen of Mr. Fiske. What we want to know now is, what it teaches us apart from lessons in literary style and arrangement.

* Compare Maudsley's theory of an all-pervading mentifercus ether, "Body and Will," p. 101.

In examining this work, small as it is, we seem to discover, as it were, traces of collaboration. It has the appearance of having been written not by one Mr. Fiske, but by two Mr. Fiskes. The first is Mr. Fiske, the simple student of science and recorder of scientific facts; the second is an author who apparently can not rest content with facts as they are, but constantly strives to view them in the light of some foreign hypothesis. The second Mr. Fiske would appear to have edited the first rather than the first the second; yet the work has been done in such a way that the diverse elements can easily be distinguished and separated.

The scientific Mr. Fiske discourses thus: As the Copernican theory destroyed the notion that the earth was infinitely larger than all the heavenly bodies, and was the center of the universe, thus giving a violent shock to the theological beliefs of the period, so the Darwinian theory to-day has destroyed the notion, prevalent up to the present time, that man occupies a position wholly apart from the rest of the animal creation. It enables us to state that "man is not only a vertebrate, a mammal, and a primate, but [that] he belongs, as a genus, to the catarrhine family of apes"; further, that "the various genera of platyrrhine and catarrhine apes, including man, are doubtless descended from a common stock of primates, back to which we may also trace the converging pedigrees of monkeys and lemurs, until their ancestry becomes indistinguishable from that of rabbits and squirrels." There is no more reason for supposing that this conclusion will ever be overthrown than there is for supposing that the Copernican theory will be banished and the Ptolemaic restored. The facts which once furnished support to the "argument from design" have received at the hands of Mr. Darwin a very different interpretation. It is "that simple but wasteful process of survival of the fittest," which is now invoked to explain the marvels of adaptation with which Nature abounds. "The scientific Darwinian theory alleges development only as the result of certain rigorously defined agencies. The chief among these agencies is natural selection." A point, however, arrived, in the development of the brute-ancestor of man, when psychical changes began to be of more use to him than physical changes; in other words, when better-developed brains began to have the advantage over better-developed muscles. From that point onward the brains of our progenitors steadily increased "through ages of ceaseless struggle," not only in size but in complexity of structure. So far, therefore, as man was concerned, "the process of zoölogical change had come to an end, and a process of psychological change was to take its place." A difference in kind was thus established between man and the lower animals, the result of the accumulation of differences of degree. In the same way we see a difference in kind established between a nebula and a solid sphere through the operation of a gradual process of cooling and contraction. Upon this point there should be no mistake, for it is thus that all differences

in kind are brought about. The result of the increasing size and complexity of the human brain, and the corresponding variety in human life, was that human beings could no longer be born in possession of full adult faculties. Infancy thus supervened as an accompaniment of increasing intellectuality. During infancy and youth the child *learns* what inheritance has not yet incorporated in its organization. Infancy, however, as a stage in individual life, is not confined to the human species. The man-like apes of Africa begin life as helpless babies, and are unable to walk, to feed themselves, or to grasp objects with precision until they are two or three months old. The difference between these and man is that the latter has a much increased cerebral surface, while the infancy of his progeny is correspondingly prolonged. Our earliest human ancestors lived, during an entire geologic æon, "a fierce and squalid existence." Yet even during that time was there progress; cerebral surface was increasing and babyhood was lengthening. "The process of evolution is excessively slow, and its ends are achieved at the cost of enormous waste of life"; still, for innumerable ages its direction has been toward the enriching, the diversifying, and the ennobling of human existence.

Discussing "the origins of society and morality," the exponent of the Darwinian theory tells us that "the psychical development of humanity since its earlier stages has been largely due to the reaction of individuals upon one another, in those various relations which we characterize as social." Infancy created the family, and the family, by taming, in a measure, individual selfishness, founded morality. The individual once brought under the law of the family, must begin to judge of his conduct by some standard outside of himself; "hence the germs of conscience and of the idea of duty." Society has thus led to a great improvement in the quality of individual life; it has made it possible for the world to have a Shakespeare, the difference between whose brain, taking creasing into account, and that of an Australian savage, "would doubtless be fifty times greater than the difference between the Australian's brain and that of an orang-outang." Such is the measure of our intellectual progress. On the moral side humanity can boast such leaders as Howard and Garrison. Yet the psychical development of man is not at an end. It is destined to go on, making not only intelligence greater, but sympathy stronger and more profound. It is true that the eliminating of strife "has gone on with the extreme slowness that marks all the world of evolution." Still, such a process is in operation, and upon it we build our hopes for the perfection of humanity.

So far the expounder of science. It will be observed that the statements he makes are either indisputable, or rest upon grounds of much apparent solidity. In connection with everything that he advances, there is an implicit appeal to verification. "If these things are not so," he seems to say, "then what are the facts?" It will be observed, also, that we are presented with no strained conclusions, with no glosses on

the text, with no doubtful or misleading metaphors, with no unwarranted suggestions. We have intelligible views, plainly and candidly expressed. The destiny of man is fairly considered in the light of his origin; but, as his origin occurred on earth, so in what precedes his "destiny" is discussed as a question of development and progress on the earth. It is modestly suggested, by no means dogmatically affirmed—the author herein agreeing with Mr. Spencer—that the influences that have raised mankind from brutehood to his present condition have not yet expended their force, but will carry him forward to further and indefinite developments of intelligence and morality.

Pass we now to consider the ideas presented, as it would almost seem, by a second Mr. Fiske, who undertakes the task of rendering innocuous or even edifying all that the first has put forward. Here we find what may perhaps best be described as a constant attempt to cut a larger garment than the cloth will allow. It is science that is supposed to supply the cloth, but, when science stints the measure, poetry and sentiment are laid under contribution. Much is done by way of suggestion, and points are so skillfully made that we need to be constantly on our guard lest we be led to mistake for knowledge what in reality is mere conjecture, or the expression of emotional longing.

But to proceed. In the preface we have a full admission that the question of a future life lies "outside the range of legitimate scientific discussion." At the same time it is maintained that we may have an "opinion" on the subject, and that our opinion on such a question "must necessarily be affected by the total mass of our opinions on the questions which lie within the scope of scientific inquiry." Here issue may be joined. If "the total mass of our opinions" on questions lying "within the scope of scientific inquiry" can guide us to an opinion on the question of a future life, then that question itself can not be said to lie "outside the range of legitimate scientific discussion." If, on the other hand, the laws and analogies which science reveals do *not* bear upon this question, then it is vain to talk of our conclusions thereon being affected by the total mass of our opinions, upon matters falling within the domain of science. In other words, there either is or is not a bridge between such questions as science commonly deals with and this question of immortality. If there is, let us walk over it and possess the farther land; if there is not, let us recognize the fact, and not pretend that the laws of the physical region throw any light on questions lying beyond that region. An "opinion" on such a matter, moreover, is not worth entertaining unless we can hope for some verification of it; and we only cheat ourselves by framing "opinions" and trying to think that in some remote way they have the sanction and support of science. It might also, with some show of reason, be maintained that mere opinions on such a point are likely to do a great deal of harm, since they are apt to stand in the way of the following out of a consistent line of thought and conduct. A man

who has merely an "opinion" is not bound by it one way or another. He may neglect the future life in the interest of the present, or the present in the alleged interest of the future, just as the inclination of the moment may lead him. The great works of the past were not wrought on the strength of an "opinion" in regard to this matter; nor will opinion lead to any great works in the present day. The work of the world in all ages has called for convictions, and it calls for them still. It is a somewhat singular thing that our author should have used the expression, "the total mass of our *opinions* on the questions which lie within the scope of scientific inquiry." The word "knowledge," I respectfully submit, was required in this place. It is our *knowledge* that can guide us to *opinions*, or, in other words, that can determine for us questions as to preponderance of evidence. An opinion that is based upon an opinion is too unsubstantial a thing to deserve any attention. The only advantage I can see in the use of the word "opinions" in the place indicated is, that it seems in a manner to help to bridge over the gap between the scientific and the non-scientific regions. The bridge, however, will not hold: it may be pretty to look at, but it has no firm anchorage.

As we have already seen, the Copernican theory destroyed the notion that man's abode, the earth, was the center of the universe. The very foundations of theology seemed at the time to have been shaken; but to-day "the speculative necessity for man's occupying the largest and most central spot in the universe is no longer felt." Upon this it may be observed that what disturbed our forefathers was not the conflict between the Copernican teaching and any speculative necessity of the period, but the conflict between that teaching and the plain declarations of the Scriptures. That was the trouble. Mr. Fiske tells us that the alarm was unnecessary—that the foundations of Christian theology have not really been shaken thereby. Possibly that is the best view to take of it, seeing that the matter can not be mended.

The reason why atheism is so abhorrent to us, why "we are wont to look upon it with unspeakable horror and loathing," is that "on its practical side it would remove humanity from its peculiar position in the world, and make it cast in its lot with the grass that withers and the beasts that perish." Can this statement, I ask, be soberly made by a man of science speaking in the name of science? In what sense does atheism—a form of belief with the truth or falsity of which we need not at present concern ourselves—remove humanity from any peculiar position distinctly, and on scientific grounds, shown to belong to it? The fact is, that if atheism went counter simply to any established tenet of science, it would excite not "unspeakable loathing and horror," but simply feelings of mingled amusement, pity, and contempt. There was unspeakable "horror and loathing" at Athens when it was found one morning that the statues of the god Hermes had been mutilated during the preceding night; but no such feelings

had stood in the way of the order given a few years earlier for the massacre of the whole male population of the flourishing city of Mytilene, or (though that order was rescinded *on grounds of policy*) of the putting to death in cold blood of one thousand Mytilenian prisoners! It is an unfortunate circumstance that "horror and loathing" have too generally been bestowed not upon atrocious crimes against humanity, but upon alleged offenses against the higher powers—in reality, upon affronts offered to theological opinion or prejudice.

The "peculiar position" of humanity is what it is, and neither atheism nor any other "ism" can make it other than it is. It is for us to discover, as far as may be, what our position is, and calmly to abide by our conclusions in the matter as long as they continue to recommend themselves to our reason. If we find that certain contrary views inspire us with "unspeakable horror and loathing" instead of with a sense of error and a desire to remove the error, we shall do well to examine ourselves as to whether we really be in the faith, whether we are not trying to atone by "horror and loathing" for indeterminateness of conviction and a deficient sense of intellectual wholeness and integrity. Such tempestuous emotions are not generally of good omen.

We can dispense, we are told, with the idea that our earth is the great cosmical center, because science now re-establishes our dignity by showing that the sun is but our Titan-like servant. Can it truly be said that science reveals this? I doubt very much that science establishes a servant-like relation of the sun to the earth. Poetry may do it; theology may try it as a *pis aller;* but science, unless my ignorance on such subjects is even greater than I take it to be, tells us no more than that the sun and the earth are parts of one system, fragments of one original nebula in different stages of evolution; and that, while the sun nourishes life upon our planet, it leaves the moon an arid waste; that, while it scorches Mercury with unbearable heat and shrouds it in almost impenetrable splendor, it sends to Uranus and Neptune but faintest pulses of light and warmth, not sufficient for any maintenance of life. Looking at the general arrangement of the solar system and the general action of terrestrial forces, it seems but trifling to pretend that human life is in any sense an explanation of the scheme as a whole, or that man's interests have been studied in any especial manner. Such a statement may seem to border on that doctrine which, as our author tells us, justly excites "unspeakable horror and loathing"; but, with all respect, I venture to express the contrary opinion, that it is a doctrine calculated to have a better moral effect than the one he labors to support. It is a doctrine which, while it tends to abate human egotism, tends also to increase our sense of responsibility. If our life is the grand culmination of creation, and if the creative power has special designs concerning us, our destinies are largely, if not wholly, taken out of our own hands. We become at once "a royal priesthood,

a peculiar people." Nothing henceforth is too good for us, no "waiting upon Providence" unjustifiable. If, on the other hand, we have no guarantee that we are in any special sense the nurslings of Heaven, then it rests with us to make the best of whatever endowments we find ourselves actually possessing. We dismiss conceit from our minds, and apply ourselves simply to know what is, in order that we may be able to exert the widest and most potent influence possible on our environment.

In further illustration of the superior dignity of our planet, it is observed that "that divine spark, the soul, as it takes up its brief abode in this realm of fleeting phenomena, chooses not the central sun where elemental forces forever blaze and clash, but selects an outlying terrestrial nook," etc. Admitting that the soul had a free choice in the matter, we must credit it with a good deal of sense in not betaking itself to a globe in which it could never by any possibility have found a body. But again, I ask, is this the voice of Science? No; it is the voice of the non-scientific and theological Mr. Fiske, who has undertaken to edit, much to the latter's hurt, the scientific Mr. Fiske. I really do not believe that the scientific Mr. Fiske knows anything about any exercise of choice by the soul as to what sphere it should inhabit. The latter simply knows that, under certain terrestrial conditions, what we commonly call "soul" manifests itself—no more.

A fine sentiment is uttered in the following passage: "To pursue unflinchingly the methods of science requires dauntless courage and a faith that nothing can shake. Such courage and such loyalty to Nature brings its own reward." Then what is the "own reward" of such admirable conduct? It is that we are enabled to see distinctly "for the first time how the creating and perfecting of man is the goal toward which Nature's work has all the while been tending." Here I must enter a respectful protest. I can not conceive that any special conclusion whatever, however edifying or comfortable, can be correctly spoken of as the natural (for that is the force here of "own") reward of loyalty to truth. If loyalty to truth brings *its own reward*, that reward can only consist in a confirmed habit of intellectual sincerity, and whatever of other moral excellence springs from such loyalty. Surely the strict scientific stand-point which our author promised to maintain has been badly deserted, when we are told that, if we are only loyal to truth, all our conclusions will come out in the most satisfactory shape. "Be loyal to truth," I should prefer to say, "and your reward will be that you will discover the truth in larger measure than you would otherwise do, and will have the signal advantage of being able to adapt your life to the truth instead of to fiction." That, in connection with strengthened moral character, seems to me to be the appropriate reward of loyalty to the truth, not the confirmation of any cherished theories. "The Darwinian theory," we are told, "makes it (human life) seem more than ever the chief object of that

creative activity which is manifested in the physical universe." But really from the scientific stand-point we are not much concerned with what things can be made to *seem;* we are concerned with what they can be proved to be. Opinion can not take the place of knowledge, nor yet of belief; and, in regard to all such questions, only knowledge and belief are of any avail. Prove to us that such and such things are so: well and good—our minds yield to evidence. Persuade us that they have been supernaturally revealed: well and good also—our minds take the desired set. But give us only probable opinions, the product of a kind of pseudo-scientific casuistry, and you do nothing for us at all, except perhaps diminish in some degree our sense for truth and reality.

The word "seem," above emphasized, may be said to furnish the key-note of the whole of what may be called the apologetic element in the work before us. The first Mr. Fiske tells us what things are, and how they have come to be what they are. The second tells us what they seem like to those who wish to think that the foundations of Christian theology have not been disturbed either by the Copernican astronomy or the Darwinian theory of the origin of species. The weakness of this kind of thing is that it may be worked in any direction and in any interest. Say what you want things to seem like, and they can easily be made to assume the desired complexion. Take an example. After animals have been devouring one another and starving one another out of existence for long ages, there appears an animal who assumes a predominance which he never afterward loses, and who goes on increasing his power and improving his position from century to century. Well, if one wishes to believe that the object toward which all this inter-mastication and inter-starvation of the myriad tribes of earth and air and sky was tending was the production of man, himself for long ages one of the most hideous of animals, there is no obstacle in the way except the complete lack of evidence in a positive sense plus the fact that the inter-mastication and inter-starvation are still going on now that man has come. If any one chooses to describe natural selection as a "simple and wasteful process," and then to say that it is "a slow and subtile" one, there is no obstacle in the way except the contrast which common sense establishes between simplicity and subtilty. If any one chooses to say that "the whole creation has been groaning and travailing together in order to bring forth that last consummate specimen of God's handiwork, the human soul," let him; for the phrase, if not scientific, is at least apostolic. Under the *régime* of "seems," a great deal can be done that is quite impossible under the unaccommodating rule of "is."

Take, for a moment, this expression of the creation "groaning and travailing together." What idea does it convey to which science gives the faintest confirmation? So far as we have any acquaintance with the facts, they are better expressed by the Lucretian idea of endless

combinations in endless series. There was groaning enough to be sure, by the way, but who can tell us, as a sober fact, that this groaning was an expression of Nature's effort to produce man, or that Nature is capable of any "effort," as we understand the word? Let us not mix up our poetry with our science. If we wish to think of Nature as groaning and travailing, we are at liberty to do so; but let us remember that in indulging such a conception we are poetizing, not adhering to scientific facts. "We are not dealing," says our author, "with vague general notions of development, but with the scientific Darwinian theory." All right, belay! Keep the sails just in that trim, and we shall get to some port of scientific truth, provided always the strict Darwinian theory is itself based on truth. As far as I am aware, Darwin himself had not caught sight, up to the time of his death, of any groaning and travailing of Nature over the work of producing the human soul.

There are a great many phrases and suggestions throughout the volume before us, besides those already noted, which might be quoted as showing the intention of the writer to make a kind of Darwinian philosophy *à l'usage des familles*. My space, however, is so nearly exhausted that I must pass over all but one of these. On page 117 we read that "the greatest philosopher of modern times, the master and teacher of all who shall study the process of evolution for many a day to come, holds that the conscious soul is not the product of a collocation of material particles, but is, in the deepest sense, a divine effluence." This I do not hesitate to say is a misrepresentation, involuntary, no doubt, of Mr. Spencer's position. If there is any meaning in language, it makes Mr. Spencer ascribe a special divinity to mind. Mr. Spencer, however, does nothing of the kind; he holds that there is one unknowable, unconditioned being, and that this manifests itself in the two conditioned forms of mind and matter. The material particles, therefore, can claim, according to his system of thought, just as much divinity of origin as the mind or soul itself. The word "divine," moreover, is not a word to the use of which Mr. Spencer is prone, and I could not readily turn to any passage in which he employs it to express any idea of his own. He speaks in his recent articles of "an Infinite and Eternal Energy"; but of the mind, in particular, as "a divine effluence," he does not speak. To say, therefore, so positively that Mr. Spencer regards the mind as "in the deepest sense a divine effluence," and that in distinction to the body, is not fair, to say the least, to the distinguished philosopher to the exposition of whose views Mr. Fiske has devoted his own most serious labors.

The conclusion of the whole matter appears to be this, that there is nothing to be gained by trying to read old theology into new science. It may be, as Mr. Fiske affirms, that the foundations of Christian theology have not been shaken—no one needs to be dogmatic on that point—but, as theology is a matter of revelation and science a matter

of observation, it is well to keep the two as separate as possible. The method of science is a gradual method: little by little, we widen the circle of our knowledge; little by little, we improve our hypotheses. Theology makes from the first the most comprehensive statements, and offers solutions of the profoundest problems. To apply, therefore, the dicta or the general conceptions of theology to the province of science is to run much risk of injuring the work of science by the forcing of premature conclusions; admitting that theology has nothing to teach that is positively erroneous. That loyalty to truth so fittingly referred to by our author requires us to content ourselves with such conclusions as we can reach by lawful and appropriate methods. If we see a law of natural selection at work, let us try to get as clear an understanding as possible of the manner of its working; but let us be very careful how we personify it, and how we impute to our personification feelings and purposes which correspond with nothing in the facts as we know them. Nothing could be more opposed to the human idea of "work" than the process of natural selection as described by our author himself, yet he constantly speaks of the "work" of natural selection. He tells us that "in the desperate struggle for existence no peculiarity has been too insignificant for natural selection to seize and enhance"; just as if natural selection were some vigilant intelligence watching for opportunities to advance its designs. The same fact which is thus expressed in, as I think, misleadingly metaphorical language could have been expressed in honest prose by saying that "in the desperate struggle for existence no peculiarity was too insignificant to contribute to survival *or destruction* as the case might be." There we have the fact without any illegitimate implications; and it is thus, as it strikes me, that scientific facts should be described. Species were formed, if the theory of natural selection is sound, in very much the same way in which the corners are ground off bowlders carried down by glaciers or swept away by torrents. Whatever projections happen to be in the way are knocked off; finally, the stone is reduced to a shape in which it is comparatively safe from further injury by friction. So with species. Darwin has discovered no law in nature by which good qualities (as such) are produced; he has simply discovered a law by which all kinds of qualities (differentiations), good, bad, and indifferent, are produced, and by which the bad ones (bad, i. e., in relation to the environment) are knocked off, like so many projecting angles, by the destruction of the individuals manifesting them. Mr. Fiske tells us that, for a long time past, so far as man is concerned, natural selection has been unable by itself to "rectify any particular unfitness." It never could rectify unfitness at any time; as Mr. Fiske tells us, on the very next page, "it always works by death." We might compare it to a physician who went about "rectifying" diseases by cutting the throats of his patients. Such drastic surgery might doubtless improve the aver-

age health of the community, but the process could scarcely be called curative or rectifying.

If, therefore, we believe in natural selection, let us believe in it as it is, and be content to speak of it as it is. *Let us not make a god of what is, in its essence, the very negation of intelligent action.* In regard to the doctrine of immortality, there is little need for alarm, so far as the teachings of science are concerned. Science does not attack it; and if the theological grounds on which it has been received hold good, then the doctrine holds good. Let us have our own teleology if we will, only let us not mix it up with our science, seeing that it can only embarrass the growth of the latter. All will be well if we keep everything in its own place, observing proper metes and bounds.

FOOD AND FEEDING.

By GRANT ALLEN.

WHEN a man and a bear meet together casually in an American forest, it makes a great deal of difference, to the two parties concerned at least, whether the bear eats the man or the man eats the bear. We haven't the slightest difficulty in deciding afterward which of the two, in each particular case, has been the eater, and which the eaten. Here, we say, is the grizzly that ate the man; or, here is the man that smoked and dined off the hams of the grizzly. Basing our opinion upon such familiar and well-known instances, we are apt to take it for granted far too readily that between eating and being eaten, between the active and the passive voice of the verb *edo*, there exists necessarily a profound and impassable native antithesis. To swallow an oyster is, in our own personal histories, so very different a thing from being swallowed by a shark that we can hardly realize at first the underlying fundamental identity of eating with mere coalescence. And yet, at the very outset of the art of feeding, when the nascent animal first began to indulge in this very essential animal practice, one may fairly say that no practical difference as yet existed between the creature that ate and the creature that was eaten. After the man and the bear had finished their little meal, if one may be frankly metaphorical, it was impossible to decide whether the remaining being was the man or the bear, or which of the two had swallowed the other. The dinner having been purely mutual, the resulting animal represented both the litigants equally; just as, in cannibal New Zealand, the chief who ate up his brother chief was held naturally to inherit the goods and chattels of the vanquished and absorbed rival, whom he had thus literally and physically incorporated.

A jelly-speck, floating about at his ease in a drop of stagnant

water under the field of a microscope, collides accidentally with another jelly-speck who happens to be traveling in the opposite direction across the same miniature ocean What thereupon occurs? One jelly-speck rolls itself gradually into the other, so that, instead of two, there is now one; and the united body proceeds to float away quite unconcernedly, without waiting to trouble itself for a second with the profound metaphysical question, which half of it is the original personality, and which half the devoured and digested. In these minute and very simple animals there is absolutely no division of labor between part and part; every bit of the jelly-like mass is alike head and foot and mouth and stomach. The jelly-speck has no permanent limbs, but it keeps putting forth vague arms and legs every now and then from one side or the other; and with these temporary and ever-dissolving members it crawls along merrily through its tiny drop of stagnant water. If two of the legs or arms happen to knock up casually against one another, they coalesce at once, just like two drops of water on a window-pane, or two strings of treacle slowly spreading along the surface of a plate. When the jelly-speck meets any edible thing—a bit of dead plant, a wee creature like itself, a microscopic egg—it proceeds to fold its own substance slimily around it, making, as it were, a temporary mouth for the purpose of swallowing it, and a temporary stomach for the purpose of quietly digesting and assimilating it afterward. Thus what at one moment is a foot may at the next moment become a mouth, and at the moment after that again a rudimentary stomach. The animal has no skin and no body, no outside and no inside, no distinction of parts or members, no individuality, no identity. Roll it up into one with another of its kind, and it couldn't tell you itself a minute afterward which of the two it had really been a minute before. The question of personal identity is here considerably mixed.

But as soon as we get to rather larger creatures of the same type, the antithesis between the eater and the eaten begins to assume a more definite character. The big jelly-bag approaches a good many smaller jelly-bags, microscopic plants, and other appropriate foodstuffs, and, surrounding them rapidly with its crawling arms, envelops them in its own substance, which closes behind them and gradually digests them. Everybody knows, by name at least, that revolutionary and evolutionary hero, the amœba—the terror of theologians, the pet of professors, and the insufferable bore of the general reader. Well, this parlous and subversive little animal consists of a comparatively large mass of soft jelly, pushing forth slender lobes, like threads or fingers, from its own substance, and gliding about, by means of these tiny legs, over water-plants and other submerged surfaces. But though it can literally turn itself inside out, like a glove, it still has some faint beginnings of a mouth and stomach, for it generally takes in food and absorbs water through a particular part of its surface, where the slimy mass of its body is thinnest. Thus the amœba may be said

really to eat and drink, though quite devoid of any special organs for eating or drinking.

The particular point to which I wish to draw attention here, however, is this: that even the very simplest and most primitive animals do discriminate somehow between what is eatable and what isn't. The amœba has no eyes, no nose, no mouth, no tongue, no nerves of taste, no special means of discrimination of any kind; and yet, so long as it meets only grains of sand or bits of shell, it makes no effort in any way to swallow them; but the moment it comes across a bit of material fit for its food, it begins at once to spread its clammy fingers around the nutritious morsel. The fact is, every part of the amœba's body apparently possesses, in a very vague form, the first beginnings of those senses which in us are specialized and confined to a single spot. And it is because of the light which the amœba thus incidentally casts upon the nature of the specialized senses in higher animals that I have ventured once more to drag out of the private life of his native pond that already too notorious and obtrusive rhizopod.

With us lordly human beings, at the extreme opposite end in the scale of being from the microscopic jelly-specks, the art of feeding and the mechanism which provides for it have both reached a very high state of advanced perfection. We have slowly evolved a tongue and palate on the one hand, and French cooks and *pâté de foie gras* on the other. But while everybody knows practically how things taste to us, and which things respectively we like and dislike, comparatively few people ever recognize that the sense of taste is not merely intended as a source of gratification, but serves a useful purpose in our bodily economy, in informing us what we ought to eat and what to refuse. Paradoxical as it may sound at first to most people, nice things are, in the main, things that are good for us, and nasty things are poisonous or otherwise injurious. That we often practically find the exact contrary the case (alas!) is due, not to the provisions of nature, but to the artificial surroundings in which we live, and to the cunning way in which we flavor up unwholesome food, so as to deceive and cajole the natural palate. Yet, after all, it is a pleasant gospel that what we like is really good for us, and, when we have made some small allowances for artificial conditions, it is in the main a true one also.

The sense of taste, which in the lowest animals is diffused equally over the whole frame, is in ourselves and other higher creatures concentrated in a special part of the body, namely, the mouth, where the food about to be swallowed is chewed and otherwise prepared beforehand for the work of digestion. Now, it is, of course, quite clear that some sort of supervision must be exercised by the body over the kind of food that is going to be put into it. Common experience teaches us that prussic acid and pure opium are undesirable food-stuffs in large quantities; that raw spirits, petroleum, and red lead should be spar-

ingly partaken of by the judicious feeder; and that even green fruit, the bitter end of cucumber, and the berries of deadly nightshade are unsatisfactory articles of diet when continuously persisted in. If, at the very outset of our digestive apparatus, we hadn't a sort of automatic premonitory adviser upon the kinds of food we ought or ought not to indulge in, we should naturally commit considerable imprudences in the way of eating and drinking—even more than we do at present. Natural selection has therefore provided us with a fairly efficient guide in this respect in the sense of taste, which is placed at the very threshold, as it were, of our digestive mechanism. It is the duty of taste to warn us against uneatable things, and to recommend to our favorable attention eatable and wholesome ones; and, on the whole, in the spite of small occasional remissness, it performs this duty with creditable success.

Taste, however, is not equally distributed over the whole surface of the tongue alike. There are three distinct regions or tracts, each of which has to perform its own special office and function. The tip of the tongue is concerned mainly with pungent and acrid tastes; the middle portion is sensitive chiefly to sweets and bitters; while the back or lower portion confines itself almost entirely to the flavors of roast meats, butter, oils, and other rich or fatty substances. There are very good reasons for this subdivision of faculties in the tongue, the object being, as it were, to make each piece of food undergo three separate examinations (like "smalls," "mods," and "greats" at Oxford), which must be successively passed before it is admitted into full participation in the human economy. The first examination, as we shall shortly see, gets rid at once of substances which would be actively and immediately destructive to the very tissues of the mouth and body; the second discriminates between poisonous and chemically harmless food-stuffs; and the third merely decides the minor question whether the particular food is likely to prove then and there wholesome or indigestible to the particular person. The sense of taste proceeds, in fact, upon the principle of gradual selection and elimination; it refuses first what is positively destructive, next what is more remotely deleterious, and finally what is only undesirable or over-luscious.

When we want to assure ourselves, by means of taste, about any unknown object—say a lump of some white stuff, which may be crystal, or glass, or alum, or borax, or quartz, or rock-salt—we put the tip of the tongue against it gingerly. If it begins to burn us, we draw it away more or less rapidly, with an accompaniment in language strictly dependent upon our personal habits and manners. The test we thus occasionally apply, even in the civilized adult state, to unknown bodies, is one that is being applied every day and all day long by children and savages. Unsophisticated humanity is constantly putting everything it sees up to its mouth in a frank spirit of experimental inquiry as to

its gustatory properties. In civilized life, we find everything ready labeled and assorted for us; we comparatively seldom require to roll the contents of a suspicious bottle (in very small quantities) doubtfully upon the tongue in order to discover whether it is pale sherry or Chili vinegar, Dublin stout or mushroom ketchup. But in the savage state, from which, geologically and biologically speaking, we have only just emerged, bottles and labels do not exist. Primitive man, therefore, in his sweet simplicity, has only two modes open before him for deciding whether the things he finds are or are not strictly edible. The first thing he does is to sniff at them, and smell being, as Mr. Herbert Spencer has well put it, an anticipatory taste, generally gives him some idea of what the thing is likely to prove. The second thing he does is to pop it into his mouth, and proceed practically to examine its further characteristics.

Strictly speaking, with the tip of the tongue one can't really taste at all. If you put a small drop of honey or of oil of bitter-almonds on that part of the mouth, you will find (no doubt to your great surprise) that it produces no effect of any sort; you only taste it when it begins slowly to diffuse itself, and reaches the true tasting region in the middle distance. But, if you put a little cayenne or mustard on the same part, you will find that it bites you immediately—the experiment should be tried sparingly—while if you put it lower down in the mouth you will swallow it almost without noticing the pungency of the stimulant. The reason is, that the tip of the tongue is supplied only with nerves which are really nerves of touch, not nerves of taste proper; they belong to a totally different main branch, and they go to a different center in the brain, together with the very similar threads which supply the nerves of smell for mustard and pepper. That is why the smell and taste of these pungent substances are so much alike, as everybody must have noticed; a good sniff at a mustard-pot producing almost the same irritating effects as an incautious mouthful. As a rule, we don't accurately distinguish, it is true, between these different regions of taste in the mouth in ordinary life; but that is because we usually roll our food about instinctively, without paying much attention to the particular part affected by it. Indeed, when one is trying deliberate experiments in the subject, in order to test the varying sensitiveness of the different parts to different substances, it is necessary to keep the tongue quite dry, in order to isolate the thing you are experimenting with, and prevent its spreading to all parts of the mouth together. In actual practice this result is obtained in a rather ludicrous manner—by blowing upon the tongue, between each experiment, with a pair of bellows. To such undignified expedients does the pursuit of science lead the ardent modern psychologist. Those domestic rivals of Dr. Forbes Winslow, the servants, who behold the enthusiastic investigator alternately drying his tongue in this ridiculous fashion, as if he were a blacksmith's fire, and then squeezing out a single drop of

essence of pepper, vinegar, or beef-tea from a glass syringe upon the dry surface, not unnaturally arrive at the conclusion that master has gone stark-mad, and that, in their private opinion, it's the microscope and the skeleton as has done it.

Above all things, we don't want to be flayed alive. So the kinds of tastes discriminated by the tip of the tongue are the pungent, like pepper, cayenne, and mustard; the astringent, like borax and alum; the alkaline, like soda and potash; the acid, like vinegar and green fruit; and the saline, like salt and ammonia. Almost all the bodies likely to give rise to such tastes (or, more correctly, sensations of touch in the tongue) are obviously unwholesome and destructive in their character, at least when taken in large quantities. Nobody wishes to drink nitric acid by the quart. The first business of this part of the tongue is, therefore, to warn us emphatically against caustic substances and corrosive acids—against vitriol and kerosene, spirits of wine and ether, capsicums and burning leaves or roots, such as those of the common English lords-and-ladies. Things of this sort are immediately destructive to the very tissues of the tongue and palate; if taken incautiously in too large doses, they burn the skin off the roof of the mouth; and when swallowed they play havoc, of course, with our internal arrangements. It is highly advisable, therefore, to have an immediate warning of these extremely dangerous substances, at the very outset of our feeding apparatus.

This kind of taste hardly differs from touch or burning. The sensibility of the tip of the tongue is only a very slight modification of the sensibility possessed by the skin generally, and especially by the inner folds over all delicate parts of the body. We all know that common caustic burns us wherever it touches; and it burns the tongue, only in a somewhat more marked manner. Nitric or sulphuric acid attacks the fingers each after its own kind. A mustard-plaster makes us tingle almost immediately; and the action of mustard on the tongue hardly differs, except in being more instantaneous and more discriminative. Cantharides work in just the same way. If you cut a red pepper in two and rub it on your neck it will sting just as it does when put into soup (this experiment, however, is best tried upon one's younger brother; if made personally, it hardly repays the trouble and annoyance). Even vinegar and other acids, rubbed into the skin, are followed by a slight tingling; while the effect of brandy, applied, say, to the arms, is gently stimulating and pleasurable, somewhat in the same way as when normally swallowed in conjunction with the habitual seltzer. In short, most things which give rise to distinct tastes when applied to the tip of the tongue give rise to fainter sensations when applied to the skin generally. And one hardly needs to be reminded that pepper or vinegar placed (accidentally as a rule) on the inner surface of the eyelids produces a very distinct and unpleasant smart.

The fact is, the liability to be chemically affected by pungent or

acid bodies is common to every part of the skin; but it is least felt where the tough outer skin is thickest, and most felt where that skin is thinnest and the nerves are most plentifully distributed near the surface. A mustard-plaster would probably fail to draw at all on one's heel or the palm of one's hand, while it is decidedly painful on one's neck or chest; and a mere speck of mustard inside the eyelid gives one positive torture for hours together. Now, the tip of the tongue is just a part of one's body specially set aside for this very object, provided with an extremely thin skin, and supplied with an immense number of nerves, on purpose so as to be easily affected by all such pungent, alkaline, or spirituous substances. Sir Wilfrid Lawson would probably conclude that it was deliberately designed by Providence to warn us against a wicked indulgence in the brandy and seltzer aforesaid.

At first sight it might seem as though there were hardly enough of such pungent and fiery things in existence to make it worth while for us to be provided with a special mechanism for guarding against them. That is true enough, no doubt, as regards our modern civilized life; though, even now, it is perhaps just as well that our children should have an internal monitor (other than conscience) to dissuade them immediately from indiscriminate indulgence in photographic chemicals, the contents of stray medicine-bottles, and the best dried West India chilies. But in an earlier period of progress, and specially in tropical countries (where the Darwinians have now decided the human race made its first *début* upon this or any other stage), things were very different indeed. Pungent and poisonous plants and fruits abounded on every side. We have all of us in our youth been taken in by some too cruelly waggish companion, who insisted upon making us eat the bright, glossy leaves of the common English arum, which without look pretty and juicy enough, but within are full of the concentrated essence of pungency and profanity. Well, there are hundreds of such plants, even in cold climates, to tempt the eyes and poison the veins of unsuspecting cattle or childish humanity. There is buttercup, so horribly acrid that cows carefully avoid it in their closest-cropped pastures; and yet your cow is not usually a too dainty animal. There is aconite, the deadly poison with which Dr. Lamson removed his troublesome relatives. There is baneberry, whose very name sufficiently describes its dangerous nature. There are horse-radish, and stinging rocket, and biting wall-pepper, and still smarter water-pepper, and wormwood, and nightshade, and spurge, and hemlock, and half a dozen other equally unpleasant weeds. All of these have acquired their pungent and poisonous properties, just as nettles have acquired their sting, and thistles their thorns, in order to prevent animals from browsing upon them and destroying them. And the animals in turn have acquired a very delicate sense of pungency on purpose to warn them beforehand of the existence of such dangerous and undesirable qualities

in the plants which they might otherwise be tempted incautiously to swallow.

In tropical woods, where our "hairy quadrumanous ancestor" (Darwinian for the primeval monkey, from whom we are presumably descended) used playfully to disport himself, as yet unconscious of his glorious destiny as the remote progenitor of Shakespeare, Milton, and the late Mr. Peace—in tropical woods, such acrid or pungent fruits and plants are particularly common, and correspondingly annoying. The fact is, our primitive forefather and all the other monkeys are, or were, confirmed fruit-eaters. But to guard against their depredations a vast number of tropical fruits and nuts have acquired disagreeable or fiery rinds and shells, which suffice to deter the bold aggressor. It may not be nice to get your tongue burned with a root or fruit, but it is at least a great deal better than getting poisoned; and, roughly speaking, pungency in external nature exactly answers to the rough, gaudy labels which some chemists paste on bottles containing poisons. It means to say, "This fruit or leaf, if you eat it in any quantities, will kill you." That is the true explanation of capsicums, pimento, colocynth, croton-oil, the upas-tree, and the vast majority of bitter, acrid, or fiery fruits and leaves. If we had to pick up our own livelihood, as our naked ancestors had to do, from roots, seeds, and berries, we should far more readily appreciate this simple truth. We should know that a great many more plants than we now suspect are bitter or pungent, and therefore poisonous. Even in England we are familiar enough with such defenses as those possessed by the outer rind of the walnut; but the tropical cashew-nut has a rind so intensely acrid that it blisters the lips and fingers instantaneously, in the same way as cantharides would do. I believe that, on the whole, taking Nature throughout, more fruits and nuts are poisonous, or intensely bitter, or very fiery, than are sweet, luscious, and edible.

"But," says that fidgety person, the hypothetical objector (whom one always sets up for the express purpose of promptly knocking him down again), "if it be the business of the fore part of the tongue to warn us against pungent and acrid substances, how comes it that we purposely use such things as mustard, pepper, curry-powder, and vinegar?" Well, in themselves all these things are, strictly speaking, bad for us; but in small quantities they act as agreeable stimulants; and we take care in preparing most of them to get rid of the most objectionable properties. Moreover, we use them, not as foods, but merely as condiments. One drop of oil of capsicums is enough to kill a man, if taken undiluted; but in actual practice we buy it in such a very diluted form that comparatively little harm arises from using it. Still, very young children dislike all these violent stimulants, even in small quantities; they won't touch mustard, pepper, or vinegar, and they recoil at once from wine or spirits. It is only by slow degrees that we learn these unnatural tastes, as our nerves get blunted and our palates jaded; and

we all know that the old Indian who can eat nothing but dry curries, deviled biscuits, anchovy paste, pepper-pot, mulligatawny soup, Worcestershire sauce, preserved ginger, hot pickles, fiery sherry, and neat cognac, is also a person with no digestion, a fragmentary liver, and very little chance of getting himself accepted by any safe and solvent insurance office. Throughout, the warning in itself is a useful one; it is we who foolishly and persistently disregard it. Alcohol, for example, tells us at once that it is bad for us; yet we manage so to dress it up with flavoring matters and dilute it with water that we overlook the fiery character of the spirit itself. But that alcohol is in itself a bad thing (when freely indulged in) has been so abundantly demonstrated in the history of mankind that it hardly needs any further proof.

The middle region of the tongue is the part with which we experience sensations of taste proper—that is to say, of sweetness and bitterness. In a healthy, natural state all sweet things are pleasant to us, and all bitters (even if combined with sherry) unpleasant. The reason for this is easy enough to understand. It carries us back at once into those primeval tropical forests where our "hairy ancestor" used to diet himself upon the fruits of the earth in due season. Now, almost all edible fruits, roots, and tubers contain sugar; and therefore the presence of sugar is, in the wild condition, as good a rough test of whether anything is good to eat as one could easily find. In fact, the argument cuts both ways: edible fruits are sweet because they are intended for man and other animals to eat; and man and other animals have a tongue pleasurably affected by sugar because sugary things in nature are for them in the highest degree edible. Our early progenitors formed their taste upon oranges, mangoes, bananas, and grapes; upon sweet-potatoes, sugar-cane, dates, and wild honey. There is scarcely anything fitted for human food in the vegetable world (and our earliest ancestors were most undoubted vegetarians) which does not contain sugar in considerable quantities. In temperate climates (where man is but a recent intruder), we have taken, it is true, to regarding wheaten bread as the staff of life; but in our native tropics enormous populations still live almost exclusively upon plantains, bananas, bread-fruit, yams, sweet-potatoes, dates, cocoanuts, melons, cassava, pineapples, and figs. Our nerves have been adapted to the circumstances of our early life as a race in tropical forests; and we still retain a marked liking for sweets of every sort. Not content with our strawberries, raspberries, gooseberries, currants, apples, pears, cherries, plums, and other northern fruits, we ransack the world for dates, figs, raisins, and oranges. Indeed, in spite of our acquired meat-eating propensities, it may be fairly said that fruits and seeds (including wheat, rice, peas, beans, and other grains and pulse) still form by far the most important element in the food-stuffs of human populations generally.

But, besides the natural sweets, we have also taken to producing artificial ones. Has any housewife ever realized the alarming condition of cookery in the benighted generations before the invention of sugar? It is really almost too appalling to think about. So many things that we now look upon as all but necessaries—cakes, puddings, made dishes, confectionery, preserves, sweet biscuits, jellies, cooked fruits, tarts, and so forth—were then practically quite impossible. Fancy attempting nowadays to live a single day without sugar; no tea, no coffee, no jam, no pudding, no cake, no sweets, no hot toddy before one goes to bed; the bare idea of it is too terrible! And yet that was really the abject condition of all the civilized world up to the middle of the middle ages. Horace's punch was sugarless and lemonless; the gentle Virgil never tasted the congenial cup of afternoon tea; and Socrates went from his cradle to his grave without ever knowing the flavor of peppermint bull's-eyes. How the children managed to spend their Saturday *as*, or their weekly *obolus*, is a profound mystery. To be sure, people had honey; but honey is rare, dear, and scanty; it can never have filled one quarter the place that sugar fills in our modern affections. Try for a moment to realize drinking honey with one's whisky-and-water, or doing the year's preserving with a pot of best Narbonne, and you get at once a common measure of the difference between the two as practical sweeteners. Nowadays, we get sugar from cane and beet-root in abundance, while sugar-maples and palm-trees of various sorts afford a considerable supply to remoter countries. But the childhood of the little Greeks and Romans must have been absolutely unlighted by a single ray of joy from chocolate cream or Everton taffy.

The consequence of this excessive production of sweets in modern times is, of course, that we have begun to distrust the indications afforded us by the sense of taste in this particular as to the wholesomeness of various objects. We can mix sugar with anything we like, whether it had sugar in it to begin with or otherwise; and by sweetening and flavoring we can give a false palatableness to even the worst and most indigestible rubbish, such as plaster-of-Paris, largely sold under the name of sugared almonds to the ingenuous youth of two hemispheres. But in untouched nature the test rarely or never fails. As long as fruits are unripe and unfit for human food, they are green and sour; as soon as they ripen they become soft and sweet, and usually acquire some bright color as a sort of advertisement of their edibility. In the main, bar the accidents of civilization, whatever is sweet is good to eat—nay more, is meant to be eaten; it is only our own perverse folly that makes us sometimes think all nice things bad for us, and all wholesome things nasty. In a state of nature, the exact opposite is really the case. One may observe, too, that children, who are literally young savages in more senses than one, stand nearer to the primitive feeling in this respect than grown-up people. They

unaffectedly like sweets; adults, who have grown more accustomed to the artificial meat diet, don't, as a rule, care much for puddings, cakes, and made dishes. (May I venture parenthetically to add, any appearance to the contrary notwithstanding, that I am not a vegetarian, and that I am far from desiring to bring down upon my devoted head the imprecation pronounced against the rash person who would rob a poor man of his beer. It is quite possible to believe that vegetarianism was the starting-point of the race, without wishing to consider it also as the goal; just as it is quite possible to regard clothes as purely artificial products of civilization, without desiring personally to return to the charming simplicity of the garden of Eden.)

Bitter things in nature at large, on the contrary, are almost invariably poisonous. Strychnia, for example, is intensely bitter, and it is well known that life can not be supported on strychnia alone for more than a few hours. Again, colocynth and aloes are far from being wholesome food-stuffs, for a continuance; and the bitter end of cucumber does not conduce to the highest standard of good living. The bitter matter in decaying apples is highly injurious when swallowed, which it isn't likely to be by anybody who ever tastes it. Wormwood and walnut-shells contain other bitter and poisonous principles; absinthe, which is made from one of them, is a favorite slow poison with the fashionable young men of Paris, who wish to escape prematurely from "*le monde où l'on s'ennuie.*" But prussic acid is the commonest component in all natural bitters, being found in bitter-almonds, apple-pippins, the kernels of mango-stones, and many other seeds and fruits. Indeed, one may say roughly that the object of Nature generally is to prevent the actual seeds of edible fruits from being eaten and digested; and for this purpose, while she stores the pulp with sweet juices, she incloses the seed itself in hard, stony coverings, and makes it nasty with bitter essences. Eat an orange-pip, and you will promptly observe how effectual is this arrangement. As a rule, the outer rind of nuts is bitter, and the inner kernel of edible fruits. The tongue thus warns us immediately against bitter things, as being poisonous, and prevents us, automatically, from swallowing them.

"But how is it," asks our objector again, "that so many poisons are tasteless, or even, like sugar of lead, pleasant to the palate?" The answer is (you see, we knock him down again, as usual) because these poisons are themselves for the most part artificial products; they do not occur in a state of nature, at least in man's ordinary surroundings. Almost every poisonous thing that we are really liable to meet with in the wild state we are warned against at once by the sense of taste; but of course it would be absurd to suppose that natural selection could have produced a mode of warning us against poisons which have never before occurred in human experience. One might just as well expect that it should have rendered us dynamite-proof, or have

given us a skin like the hide of a rhinoceros to protect us against the future contingency of the invention of rifles.

Sweets and bitters are really almost the only tastes proper, almost the only ones discriminated by this central and truly gustatory region of the tongue and palate. Most so-called flavorings will be found on strict examination to be nothing more than mixtures with these of certain smells or else of pungent, salty, or alkaline matters, distinguished as such by the tip of the tongue. For instance, paradoxical as it sounds to say so, cinnamon has really no taste at all, but only a smell. Nobody will ever believe this on first hearing, but nothing on earth is easier than to put it to the test. Take a small piece of cinnamon, hold your nose tightly, rather high up, between the thumb and finger, and begin chewing it. You will find that it is absolutely tasteless; you are merely chewing a perfectly insipid bit of bark. Then let go your nose, and you will find immediately that it "tastes" strongly, though in reality it is only the perfume from it that you now permit to rise into the smelling-chamber in the nose. So, again, cloves have only a pungent taste and a peculiar smell, and the same is the case more or less with almost all distinctive flavorings. When you come to find of what they are made up, they consist generally of sweets or bitters, intermixed with certain ethereal perfumes, or with pungent or acid tastes, or with both or several such together. In this way, a comparatively small number of original elements, variously combined, suffice to make up the whole enormous mass of recognizably different tastes and flavors.

The third and lowest part of the tongue and throat is the seat of those peculiar tastes to which Professor Bain, the great authority upon this important philosophical subject, has given the names of relishes and disgusts. It is here, chiefly, that we taste animal food, fats, butters, oils, and the richer class of vegetables and made dishes. If we like them, we experience a sensation which may be called a relish, and which induces one to keep rolling the morsel farther down the throat, till it passes at last beyond the region of our voluntary control. If we don't like them, we get the sensation which may be called a disgust, and which is very different from the mere unpleasantness of excessively pungent or bitter things. It is far less of an intellectual and far more of a physical and emotional feeling. We say, and say rightly, of such things that we find it hard to swallow them; a something within us (of a very tangible nature) seems to rise up bodily and protest against them. As a very good example of this experience, take one's first attempt to swallow cod-liver oil. Other things may be unpleasant or unpalatable, but things of this class are in the strictest sense nasty and disgusting.

The fact is, the lower part of the tongue is supplied with nerves in close sympathy with the digestion. If the food which has been passed by the two previous examiners is found here to be simple and

digestible, it is permitted to go on unchallenged; if it is found to be too rich, too bilious, or too indigestible, a protest is promptly entered against it, and if we are wise we will immediately desist from eating any more of it. It is here that the impartial tribunal of nature pronounces definitely against roast goose, mince-pies, *pâté de foie gras*, sally lunn, muffins and crumpets, and creamy puddings. It is here, too, that the slightest taint in meat, milk, or butter is immediately detected; that rancid pastry from the pastrycook's is ruthlessly exposed, and that the wiles of the fishmonger are set at naught by the judicious palate. It is the special duty, in fact, of this last examiner to discover, not whether food is positively destructive, not whether it is poisonous or deleterious in nature, but merely whether it is then and there digestible or undesirable.

As our state of health varies greatly from time to time, however, so do the warnings of this last sympathetic adviser change and flicker. Sweet things are always sweet, and bitter things always bitter; vinegar is always sour, and ginger always hot in the mouth, too, whatever our state of health or feeling; but our taste for roast loin of mutton, high game, salmon cutlets, and Gorgonzola cheese varies immensely from time to time, with the passing condition of our health and digestion. In illness, and especially in sea-sickness, one gets the distaste carried to the extreme; you may eat grapes or suck an orange in the chops of the Channel, but you do not feel warmly attached to the steward who offers you a basin of greasy ox-tail, or consoles you with promises of ham-sandwiches in half a minute. Under those too painful conditions it is the very light, fresh, and stimulating things that one can most easily swallow—champagne, soda-water, strawberries, peaches, not lobster salad, sardines on toast, green Chartreuse, or hot brandy-and-water. On the other hand, in robust health, and when hungry with exercise, you can eat fat pork with relish on a Scotch hill-side, or dine off fresh salmon three days running without inconvenience. Even a Spanish stew, with plenty of garlic in it, and floating in olive-oil, tastes positively delicious after a day's mountaineering in the Pyrenees.

The healthy popular belief, still surviving in spite of cookery, that our likes and dislikes are the best guide to what is good for us, finds its justification in this fact, that whatever is relished will prove on the average wholesome, and whatever rouses disgust will prove on the whole indigestible. Nothing can be more wrong, for example, than to make children eat fat when they don't want it. A healthy child likes fat, and eats as much of it as he can get. If a child shows signs of disgust at fat, that proves that it is of a bilious temperament, and it ought never to be forced into eating it against its will. Most of us are bilious in after-life just because we were compelled to eat rich food in childhood, which we felt instinctively was unsuitable for us. We might still be indulging with impunity in thick turtle, canvas-back

ducks, deviled whitebait, meringues, and Nesselrode puddings, if we hadn't been so persistently overdosed in our earlier years with things that we didn't want and knew were indigestible.

Of course, in our existing modern cookery, very few simple and uncompounded tastes are still left to us; everything is so mixed up together that only by an effort of deliberate experiment can one discover what are the special effects of special tastes upon the tongue and palate. Salt is mixed with almost everything we eat—*sal sapit omnia*—and pepper or cayenne is nearly equally common. Butter is put into the peas, which have been previously adulterated by being boiled with mint; and cucumber is unknown except in conjunction with oil and vinegar. This makes it comparatively difficult for us to realize the distinctness of the elements which go to make up most tastes as we actually experience them. Moreover, a great many eatable objects have hardly any taste of their own, properly speaking, but only a feeling of softness or hardness, or glutinousness in the mouth, mainly observed in the act of chewing them. For example, plain boiled rice is almost wholly insipid; but even in its plainest form salt has usually been boiled with it, and in practice we generally eat it with sugar, preserves, curry, or some other strongly flavored condiment. Again, plain boiled tapioca and sago (in water) are as nearly tasteless as anything can be; they merely yield a feeling of gumminess; but milk, in which they are oftenest cooked, gives them a relish (in the sense here restricted), and sugar, eggs, cinnamon, or nutmeg are usually added by way of flavoring. Even turbot has hardly any taste proper, except in the glutinous skin, which has a faint relish; the epicure values it rather because of its softness, its delicacy, and its light flesh. Gelatine by itself is merely very swallowable—we must mix sugar, wine, lemon-juice, and other flavorings in order to make it into good jelly. Salt, spices, essences, vanilla, vinegar, pickles, capers, ketchups, sauces, chutneys, lime-juice, curry, and all the rest, are just our civilized expedients for adding the pleasure of pungency and acidity to naturally insipid foods, by stimulating the nerves of touch in the tongue, just as sugar is our tribute to the pure gustatory sense, and oil, butter, bacon, lard, and the various fats used in frying to the sense of relish which forms the last element in our compound taste. A boiled sole is all very well when one is just convalescent, but in robust health we demand the delights of egg and bread-crumb, which are after all only the vehicle for the appetizing grease. Plain boiled macaroni may pass muster in the unsophisticated nursery, but in the pampered dining-room it requires the aid of toasted parmesan. Good modern cookery is the practical result of centuries of experience in this direction; the final flower of ages of evolution, devoted to the equalization of flavors in all human food. Think of the generations of fruitless experiment that must have passed before mankind discovered that mint-sauce (itself a cunning compound of vinegar and sugar) ought to

be eaten with leg of lamb, that roast goose required a corrective in the shape of apple, and that while a pre-established harmony existed between salmon and lobster, oysters were ordained beforehand by Nature as the proper accompaniment of boiled cod! Whenever I reflect upon such things, I become at once a good Positivist, and offer up praise in my own private chapel to the Spirit of Humanity which has slowly perfected these profound rules of good living.—*Cornhill Magazine.*

SULPHUR AND ITS EXTRACTION.

By C. G. WARNFORD LOCK.

THE following notes relate exclusively to native sulphur (brimstone). Though the amount of sulphur annually mined in the form of sulphides of various metals (e. g., iron and copper pyrites, galena, blende, etc.) probably far exceeds that obtained in the uncombined state, still, the separation of the sulphur in an inoxidized condition from such compounds is never attempted, for the simple reasons that, in the processes for extracting the several metals from their ores, the first step necessary is the elimination of the combined sulphur, which is most easily effected by a roasting or oxidizing operation, whereby the sulphur is at once converted into sulphurous acid, itself a valuable commodity, and, moreover, capable of being readily oxidized one step further to form sulphuric acid, the chief purpose for which sulphur is consumed.

There are two mines of sulphur worked in Austria-Hungary, one not far from Cracow, and the other at Radoboi in Croatia; both deposits are of considerable extent, but the annual yield is insignificant. The whole district around Mount Büdös, in Transylvania, is rich in sulphur. Some thirty or more diggings have been undertaken in a circuit of eighteen miles, but the area covered by the deposits is more than three times this size. The sulphur occurs in unequal strata one to nine inches thick, beneath one to three feet of mold. The soil is everywhere saturated with sulphur, and in this permeated earth pieces of the pure mineral are found. The whole is the result of living solfataric action, and the accumulation will continue to grow as long as that action survives. Samples of the impregnated earth, taken over an area of 16,000,000 square fathoms, yielded from forty-one to sixty-four per cent of sulphur. Allowing for interruptions in the deposits, and taking these at an average thickness of three inches instead of nine, the total sulphur output of the Austrian Empire, in 1863, was 1,754 tons, at an average rate of £12 15*s.* per ton. The imports are about five thousand tons per annum.

Large quantities of sulphur are found in and about the crater of

Gunong Api, in the Banda Islands, and attempts have been made to collect it for exportation. It is said, however, that the labor of ascending the mountain is too great to render the speculation profitable.

Sulphur is one of the most important products of Formosa. When taken from the mine, the ore is boiled in iron pans till it assumes a treacly consistence. This is constantly stirred till every impurity is separated from the sulphur, which is then ladled out into wooden tubs, shaped like sugar-loaves. In these it is left to cool, and the conical cakes are freed from the tubs by the simple process of knocking out the bottoms of the latter.

Sulphur is procurable in salable quantities from the mountains around Ta-chien-la, in Western China ; the inhabitants of the ravines may often be seen engaged in the manufacture of matches of the Guy Fawkes pattern, which they split from a pine plank with a spokeshave, and tip with sulphur. During his penniless residence at Na-erh-pa, Baber generally used these sulphur chips to procure a flame.

Near the hamlet of Tappets, about three miles northeast of Apt, in the department of Vaucluse, France, is a bed of sulphur-ore yielding about twenty to twenty-five per cent. It consists of a sulphur-impregnated, marly limestone, and accompanies the lignite-beds of the tertiary system. The deposit is neither very extensive nor very thick.

The sulphur-deposits of Krisuvik, in the south of Iceland, belong to the recent solfataric group, and, though often compared with the Sicilian mines, bear very little analogy to them. The sulphur occurs in a fine state, intimately associated with earthy impurities, as a superficial layer of no great depth, but having recuperative powers that render them practically inexhaustible. They are now the property of an English company, and give promise of being worked to advantage in the future.

The sulphur-deposits of India, according to Professor V. Ball,* are unimportant, and inconveniently situated. Near a village called Sura-Sany-Yanam, between the mouths of the Godaveri, in Madras, small heaps of sulphur are occasionally collected in the dried-up margin of a tidal swamp, where the mineral appears to result from deoxidation of gypsum by contact with organic matter. Another trifling deposit is reported to occur at Ghizri Bandar, near Karachi. A considerable mine, worked by adits and chambers, exists at Sunnee in Cutchi, Beloochistan, and affords the chief supply for Candahar. Sulphur is obtained in some abundance from near a hot spring called Pir Zinda, in the Soree Pass of the Suleiman Hills, Afghanistan. A "vast quantity" of sulphur is said to occur at Hazara, North Afghanistan. On the southern flanks of the Gunjully Hills, in the Kohat district of the Punjaub, a large amount of sulphur is constantly being deposited as a result of the decomposition of pyritiferous alum-shales. As much

* "Economic Geology of India."

as one thousand tons a year is said to have been gathered. At Luni-ki-Kussi, on the west side of the Indus, sulphur is obtained by roasting the loose earth. The sulphur-mines at Nakband (Kushalgarh), on the Indus, eight miles from the mouth of the Kohat, are thirty to forty feet deep, and have yielded largely, the ore being sublimed as in Beloochistan.

The sulphur at Puga, in Kashmir, occurs massive, and as a lining in the clefts and fissures of a sort of quartz schist, often accompanied by gypsum. The process of formation seems to be still at work, judging by hot springs in the neighborhood. The deposits are worked by pits about eight feet deep, and adits of the same length; but the production is small. A trifling quantity of sulphur is deposited by hot springs in the beds of the Ramgunga and Garjia Rivers, in the Kumaun district of the Northwest Provinces; and a considerable amount is found in the galleries of the lead-mines at Meywar, on the Tons River, in the Jaunsar district. Little is known of the Nepaulese sulphur mines. In upper Burmah are several localities.

The sulphur-deposits of the Italian Romagna are situated in the Miocene lacustrine formation, and lie amid the sub-Apennine hills. The mines worked in the province of Forli, by the Cesena Sulphur Company, cover an area of about two hundred and sixty square kilometres. Their average annual production for the seven years 1873–'79 was 27,789 tons. The cost of extraction, refining, and royalties come to about four pounds per ton, according to Consul Colnaghi. The mineral is worked by blasting, each miner having to bore three holes in six hours, when all are fired simultaneously. At Pergola, some sixty kilometres distant from Ancona, is a sulphur-mine worked by a German company, which shipped ninety tons of refined sulphur to England in 1880. In Central Italy, near Bologna, a vein is worked which extends over fifteen miles in length. The ore is poor, and has to be raised from a considerable depth.

Sulphur is said to be abundant in the Japanese island of Yezo.

A good deal of sulphur is collected at Camiguin, in the Philippine Islands.

In Sicily, at the end of the Middle Miocene period, the sulphur-bearing area was raised, and lakes were formed in which occurred the deposition of the sulphur-rock and its accompanying gypsum, tripoli, and silicious limestone. The sulphur-rock is composed of sulphur and marly limestone, the sulphur being sometimes disseminated through the limestone, and at others forming thin alternate layers with it. These sulphur-bearing seams are often separated by layers of black marl, twenty inches to six feet thick, some seams attaining a thickness of twenty-eight feet. The total aggregate thickness of the sulphur-seams reaches one hundred feet in one case, but the average total is ten to twelve feet only. All the seams are decomposed at their outcrop, and show only an accumulation of whitish friable earth, called *bris-*

cale by the miners, and mainly composed of gypsum. This has resulted from the oxidation of the sulphur to sulphuric acid by atmospheric agency, the acid in turn attacking the lime carbonate, and forming sulphate (gypsum). The most plausible supposition as to the origin of the sulphur-seams would appear to be that the lakes received streams of water containing calcium sulphide in solution, this calcium sulphide probably resulting from a reduction of the masses of calcium sulphate (gypsum) by the action of volcanic heat. Gradual decomposition of the calcium sulphide in the presence of water would finally result in a deposition of sulphur and of lime carbonate, in the relative proportions of twenty-four and seventy-six per cent. As a matter of fact, much of the Sicilian ore actually has this percentage composition. Whatever the process has been, it is no longer in activity, and there is no growth nor renewal of the beds, in this respect differing essentially from recent deposits due to "living" solfataric action.

Almost all the Sicilian ore is carried to the surface on boys' backs, consequently it does not pay to work below about four hundred feet, as it then becomes necessary to employ hauling machinery. Hence the deposits lying below that horizon are hardly touched, and as many of the beds are nearly vertical, and do not diminish in yield as they descend, the still untouched resources must be very great. Various estimates have been made as to the period for which the supply will last at the present rate of consumption; these range from fifty to two hundred years. There are said to be about two hundred and fifty mines in the island, and no less than 4,367 *calcaroni* were reported in operation fifteen years ago. The average yield is stated not to exceed fourteen per cent.

In the province of Murcia, and at other places, in Spain, the existence of fine beds of sulphur has been ascertained. One is worked by an English association, the Hellin Sulphur Company. The quality is very good.

A sulphur-deposit exists at Djemsa, in a perfectly rainless desert on the African coast near Suez, very near the sea, and constituting a hill six hundred feet high, whose sides are blasted down as in quarrying stone. Some two hundred Arabs, employed under French engineers, succeeded in mining ten tons a day. A similar deposit occurs at Ranga, five hundred miles from Suez, also near the coast of the African Continent, which differs only in being buried under other strata, so that mining is necessary.

The Gunong Jollo, or sulphur mountain of the Sunda Islands, lies southwest of the village Prado, and southeast of Dompo. The sulphur is dug from three places in an old crater now in the solfataric stage of its existence. Each spot is one hundred to one hundred and twenty roods long, and fifty to sixty broad. The sulphur collects between masses of white stone (perhaps decomposed trachyte), and sometimes covers a space of one to three roods square. On the liquid and warm

sulphur a hard crust forms, two inches thick. Digging is only carried on at morning and evening, the heat being too great at midday. Round holes are made, eight to nine feet apart, two feet deep, and with an outlet from above of one foot, and from below of three or four feet. Sulphur is also found in the solfatara of Gunong Prewa, but in trifling quantity. A great deal exists on the sides of Tambora.

Tripoli possesses a sulphur-deposit important both for extent and richness, but it is not worked.

In Turkey, native sulphur is found in some quantity adjacent to the lead lodes at Devrent (Derbend), near Alashehr, Salyklœ, and Nymphi. A sulphur-mine exists two days' ride from Arta, and four from Butrinto, Albania, and there are other mines near the Dardanelles and at Alahtan, about six hours from Kassaba.

In the United States, sulphur is found native in Nevada, California, Utah, Virginia, Louisiana, and other States, and occurs in beds of considerable bulk in Uintah county, Wyoming, near Evanstown, where it is said to be quite pure; also in some quantity in the Yellowstone Park, Montana, and in various localities in New Mexico. It is only worked to any extent in Nevada and California, and even there not on a large scale, the total production in 1880 being stated at under six hundred tons. Locally produced sulphur can not compete in price with imported Sicilian, on account of the cost of land transport; it is, moreover, found to be often contaminated with arsenic, which greatly reduces its market value and limits its application. At the most important mine, called the Rabbit Hole, in Humboldt County, Nevada, the sulphur occurs as an impregnation in a white volcanic tuff or breccia, of Miocene age. The deposit is worked by regular mining, and the mineral, containing fifteen to forty per cent of sulphur, is dealt with by the steam process, the production being sometimes six tons a day. At the Pluton mines, California, the sulphur is found as a crystalline body scattered through a confused mass of decomposed rocks, and intimately associated with cinnabar, apparently occupying an ancient crater. The mineral is removed altogether, and the sulphur is either recovered by steam process, or, if both sulphur and cinnabar are in paying quantities, the mass is put into a mercury distilling furnace, and the sulphur is separated from the mercury by passing superheated steam into a chamber situated in front of the mercury-condensing chamber.

Sulphur is extracted from the earthy materials with which it is intimately associated in nature, by the following several means: 1. Dry heat (roasting the ore in mass); 2. Wet heat (melting out by the aid of aqueous solutions of salts, the salts being added to heighten the boiling-point); 3. Superheated steam; 4. Chemical solvents. The great bulk of all the sulphur produced is extracted by apparatus belonging to the first class, and including the *calcarelle, calcarone,* and *doppione.*

CALCARELLE.—The earliest system adopted in Sicily was the *calcarelle*. This consisted simply of a stack of ore six to fifteen feet square, built in a ditch three or four inches deep, and whose floor was beaten hard and sloped to a single point, permitting the molten sulphur to flow out by an opening termed the *morto*. In building the stack, care was taken to put the largest pieces of ore at the bottom, selecting lumps of gradually diminishing size as the top was approached. The mass was ignited at the summit. The construction of the stack usually occupied two days; on the third day the sulphur escaped by the *morto*, and on the fourth the *calcarelle* was pulled down. The air necessary for the combustion of a portion of the sulphur (to afford the heat required to smelt the remainder) was freely admitted at all sides; only the mineral in the center of the heap was heated without actual contact with the air, so that its sulphur was melted out instead of being burned (oxidized). Consequently about 6,700 pounds of sulphur mineral were needed to afford 385 pounds of sulphur, or a yield of 5·7 per cent; as the ore contained thirty-five per cent of sulphur, the consumption of sulphur as fuel was 1,960 pounds, in order to extract 385 pounds. In addition, the immense volumes of sulphurous acid emitted from the stack caused a terrible destruction of the agricultural crops in the neighborhood.

CALCARONE.—Nearly all the sulphur prepared in Sicily is now extracted by the *calcarone* (or *calcherone*, as it may also be spelled). This, as is shown in Figs. 1 and 2, is formed by building a circular

FIG. 1.

stone wall on an inclined sole. In front is the *morto* or outlet, having a height of four to six feet, and a width of two feet; over it is erected a wooden shelter for the workman in charge. *Calcaroni* may contain from two hundred to four hundred *casse* (each *casse* being equivalent to about six tons, and giving twelve to sixteen hundredweight of sulphur). The durability of the *calcarone* is governed by

the care exercised in its construction; ten years is not an unusual period. The charging of the *calcarone* is a matter of primary importance, as on it depends the yield of sulphur. The largest pieces of ore are selected for the first layer, leaving interstices between them; the size of the lumps gradually diminishes as the height increases, care being taken to form the walls of the *morto* with calcareous stones, so as to insure a passage being maintained for the escape of the liquefied sulphur. In adding the finest portions on the top, narrow channels, about two feet apart, are left for the draught to carry the heat down. The whole is covered with a layer of the refuse from previous operations. This layer is more or less thick, according to the state of the weather, because, the *calcarone* being built in the open air, variations of temperature and wind influence the progress of the operation; consequently means have to be adopted to prevent an undue access of air rendering the combustion too rapid. For instance, during a sirocco (local hot wind) there is danger of the sulphur contained in the ore lying at the side facing the wind being completely converted into sulphurous acid, and thus lost. The employment of a roofed shed would prevent much of the waste occasioned by climatic causes.

When the charging is completed, the *morto* is closed by a stone slab, and fire is communicated to the mass by means of little bunches of dried herbs, dipped in sulphur, which are thrust into the vertical channels before mentioned. Some six or eight days afterward, a hole is pierced in the top of the *morto*, by means of an iron rod; later, a

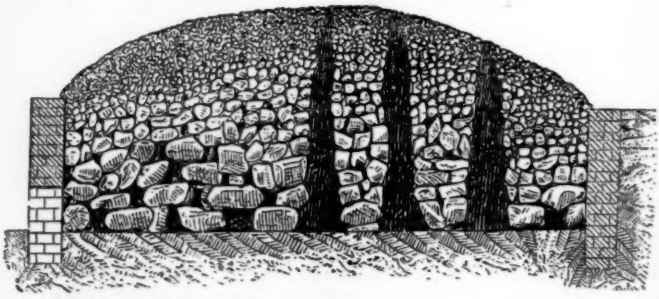


FIG. 2.

second hole is made near the floor. By these two openings the sulphur escapes, and is collected in wooden buckets (*gravite*), shaped like a truncated cone, and holding about one hundred-weight of sulphur. These buckets cost over two shillings, and serve only for three or four castings without wanting repairs. The outflow of sulphur lasts for a fortnight or a month. Commonly, the *calcarone* is left to itself when once the mass has been ignited, but then the loss of sulphur is much more serious. To insure good results, many precautions have to be observed, mainly connected with the nice adjustment of the draught, so

as to effect the maximum degree of fusion with a minimum of oxidation. When the operation is conducted during winter, the product is less abundant, and of inferior quality. After the charge is exhausted, a new one can not be introduced till the mass has cooled down, occupying a period of ten days to a month, according to the size of the *calcarone*. The discharging has to be done slowly and cautiously, on account of the sulphurous fumes liberated. The consumption of sulphur (as fuel) in the heating is about fifty per cent of the total amount contained in the ore. Thus, to obtain one ton of sulphur, there is consumed as fuel about another ton, worth say five pounds, and performing a duty which could be much more satisfactorily accomplished by two hundred-weight of coal, costing perhaps five shillings.

A great improvement in the Sicilian *calcarone* has been introduced by P. Le Neve Foster, and worked with good results, showing an increase of yield of thirty per cent above the ordinary plan. According to his description, the waste heat from an ordinary *calcarone*, after all the sulphur has been run off, is utilized to heat to the required temperature the charge of ore placed in his kiln, and, as soon as the moisture has been driven off and the heat is great enough, the charge is fired from the top. The combustion, fed with hot air containing some sulphurous-acid gas, is very slow, hence the loss of sulphur by burning is less than when, as in the ordinary *calcarone*, the ore has to be heated entirely by the combustion of the sulphur. The apparatus (shown in Fig. 3, prepared from a drawing kindly furnished me by the inventor) consists essentially of three parts: 1. The flue, or conductor of heat; 2. The kiln, in which the ore is treated; 3. The chamber for the condensation of the sulphur that is volatilized during the fusion, and in which it is collected.

The kiln may be of any suitable form to contain two charges of ore, but a rectangular chamber is found to be most convenient, with floor sloping toward the front. The chamber consists of four walls, preferably not covered with an arch, as affording greater facility for charging and discharging. The kiln communicates, by means of a flue, A, with the back of an ordinary *calcarone*, B, which furnishes the heat necessary for melting the sulphur from the one contained in the kiln, C. The upper portion of the *calcarone* should be covered with a layer of *genese* (spent ore), so as to prevent the dispersion of heat by any other channel than that offered by the flue, A, which is provided with a damper, D, so as to regulate the admission of heated air by openings, E, at the upper back part of the kiln. A rectangular opening, F, is left in the front wall of the kiln, from which the melted sulphur is run. This opening, if of sufficient size, may serve for discharging the spent ore at the termination of the fusion. From the upper part of the opening, and also in the front wall, slightly above the level of the floor, flues, G, communicate with a horizontal passage, H, which is made large enough to serve as a condensation chamber, on the walls of which

the sublimed sulphur collects. At one end of the chamber is a vertical chimney, I, provided with a damper, K.

The kiln is charged in the usual way by placing the large pieces of ore on the floor in such a manner as to leave passages for the flow of the liquid sulphur; the small pieces are next filled in, and the finer ore at the top. A few blocks of rough stone, or burned ore, are placed at the opening in front in such a way as to leave a vacant place for the melted sulphur to collect before being run off. When charged, the ore is covered with bricks laid flat, and on these is put a layer of *genese*, well rammed and wetted, so as to form a nearly impermeable

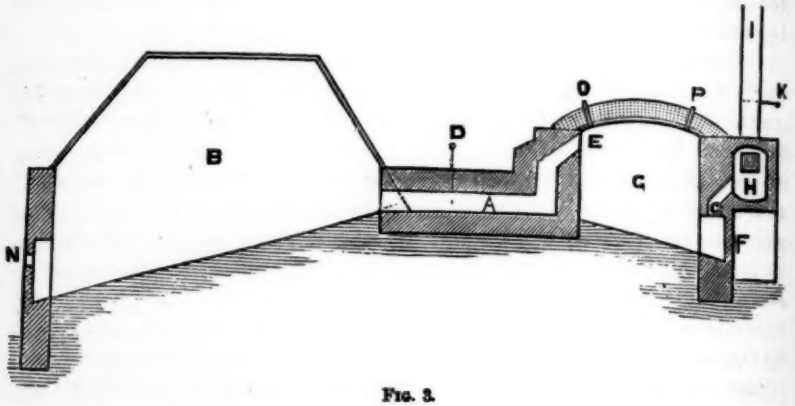


FIG. 3.

coating, with a slight slope toward the walls, in order that the rain-water may run off. The opening, F, in the front wall should be closed with a thin wall of plaster of Paris. The ore in the kiln, which is now ready for fusion, is put in communication with the spent *calcarone*, B, by opening the damper, D, and at the same time a small hole, N, is made in the wall that closes the opening in front, from which the melted sulphur has been run off from the *calcarone*, B. The current of air entering by the hole, N, and passing through the incandescent mass of ore, is thus heated, and enters the kiln by the flue, N, at a sufficient temperature. In this manner the heated mass of spent ore in the *calcarone* becomes a regenerator of heat, to be utilized in the kiln for the fusion of the sulphur that it contains. In the upper covering, two or more tubes, O P, are placed, and serve not only for observing the internal temperature by a thermometer, but also for firing the mass.

The combustion of the sulphur supplied with hot air, mixed with a considerable proportion of sulphurous-acid gas, proceeds slowly in the upper part of the kiln, and the liquid sulphur dropping to the floor, over the already heated ore, can not solidify and choke the passages, and so prevent the circulation of the heated air and products of combustion of the sulphur to the chimney; in this manner the operation proceeds with regularity. The success of the kiln is principally due to the

manner in which it is heated from the top and back toward the front and bottom, imitating, to a certain degree, the manner in which the heating of an ordinary *calcarone* proceeds, with this difference, that the heat is better utilized in the kiln, and therefore with less consumption of sulphur as fuel.

When the wall that closes the front opening, F, begins to heat, and the kiln is ready for running, a small hole is made with a pointed instrument, so as to allow the melted sulphur to flow off into wooden molds. The horizontal flue or condensing chamber, H, should have a sloping floor, and, when the temperature in it reaches the melting-point of sulphur, the flowers that have been deposited on the sides are liquefied, and run off. Toward the end of the operation it will be found prudent to close all the dampers as well as the hole, N, to prevent the overheating of the kiln, in which case the sulphur would become thick, and difficult to run off, and the yield would consequently be lessened.

The first cost of the structure is slight, as the materials necessary are usually at hand. The yield, too, is much increased; but, on the other hand, the extra cost in charging, discharging, and attendance, as compared with the ordinary *calcarone*, make a large hole in the increased returns.

It will require little reflection to see that only a small quantity of the finely pulverized mineral, necessarily produced in the operations of mining and breaking down the ore, could be dealt with in the *calcarone;* consequently, for a long time the bulk of this portion of the ore was simply thrown away, though it often assayed seventy per cent

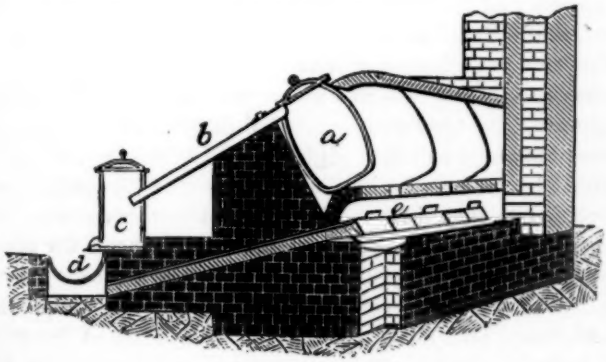


FIG. 4.

of sulphur. The *doppione* was one of the earliest successful structures designed to remedy this state of things. As shown in Fig. 4, it consists of a set (generally six) of cast-iron pots, holding about thirty to forty gallons each, arranged in a gallery furnace, *e*, so as to be completely enveloped by the heated vapors from a fire beneath. Each pot, *a*, communicates by a long arm, *b*, with a cooling condenser, *c*, for the

distilled sulphur, placed outside the furnace. The apparatus is generally employed on rich material, or on that obtained from the *calcaroni;* but it is also applicable to ores which are too poor to burn in the *calcaroni*, though the profit in that case must be small. The heat generated in the *doppione* is likely to encourage chemical action between the sulphur and any lime carbonate that may chance to be present in the mineral, creating a further loss of sulphur. The pots are charged and discharged by opening the lids, which are kept luted during the distillation. The volatilized sulphur is conducted by the cast-iron tub, *b*, into the receptacle, *c*, over which a small current of cold water constantly flows, reducing the sulphur to a fluid condition; it then escapes into the dish, *d*, beneath, whence it can be ladled into the molds. The pots last for about three hundred working-days, and the furnace serves about the same time with a couple of repairings. The workman is expected to turn out one hundred pounds of clean sulphur from every one hundred and nine pounds of *calcarone* sulphur.

The principle underlying the use of calcium chloride is that, while raising the boiling-point of water to about 239° Fahr. (115° C.), the melting-point of sulphur, it is cheap and inert in the presence of sulphur. The water to be used in the melting process is charged with sixty-six per cent of the calcium chloride, and heated to boiling, in which state it is run into the vessel containing the sulphur to be melted. No doubt the sulphur is efficiently melted, but the very slight difference in specific gravity between the sulphur and the associated impurities, from which it had been melted out, practically precludes any real separation taking place. Consequently, the process is virtually a failure, as I am assured by those who have worked it.

At the Rabbit Hole mines, Humboldt County, Nevada, advantage is taken of the liquidity of sulphur at 232° Fahr. (111° C.), to use steam at sixty to seventy pounds pressure for melting the sulphur out of the gangue. The apparatus employed consists of a cylindrical iron vessel, about ten and a half feet high, divided into an upper and a lower compartment, by means of a horizontal sheet-iron diaphragm perforated with one-fourth-inch holes. As soon as the upper compartment is charged with ore (about two tons), steam is introduced for about half an hour, and the sulphur, liquefied by the heat, flows down through the diaphragm into the lower compartment, kept at the proper heat by injection of steam, and escapes by an outlet, opened at intervals into a receptacle placed outside. When water commences to flow out with the sulphur, steam is injected at full pressure for a few minutes, to clear out as much as will come, and the solid residue is afterward removed through a door above the diaphragm. Each charge requires about three hours for its treatment. The process is adapted to ores which, for poverty and other reasons, can not be economically worked by *calcaroni*, or other recognized methods.

While hot water and steam have no solvent action upon sulphur,

but merely change it from a solid to a liquid state by the action of their heat, carbon bisulphide actually dissolves the sulphur and redeposits it by evaporation. The plant necessary for carrying out this process is shown in Fig. 5. It is designed of dimensions suitable for dealing with twenty tons of raw sulphur mineral per diem, yielding fifty per cent of pure sulphur. The four extracting pans, *a*, *b*, *c*, *d*, have each a capacity of five tons, and are made of three-eighth inch

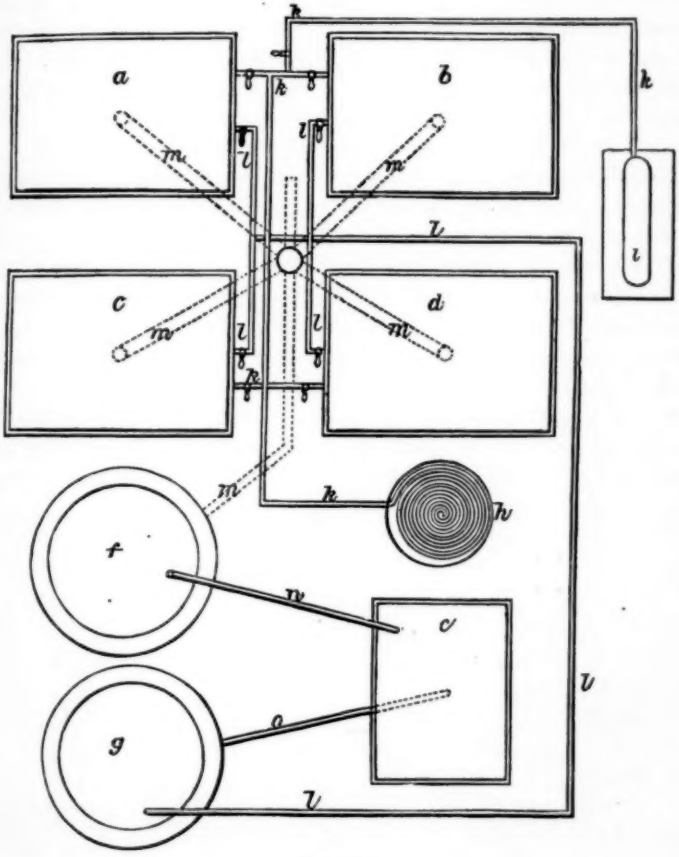


FIG. 5.

wrought-iron plate ; they measure six feet long, four feet wide, and four feet deep internally ; and are fitted with a perforated bottom diaphragm, with connecting pipes, *m*, leading to the underground solution-tank, *f*, with another set of pipes, *k*, for admitting steam from the boiler, *i*, and with a third set of pipes, *l*, communicating with the store-tank, *g*. The still, *e*, is a steam-jacketed " wrought-jacket " pan, six feet long, four feet wide, and four feet deep, with cast-iron ("loam casting ") oval-shaped bottom and ends, one-half inch thick, and pro-

vided with a dome-shaped lid, having an inlet-pipe, *n*, and outlet-pipe, *o*; its capacity is three tons. The store-tank, *g*, measures ten feet in diameter, by seven feet deep, has a capacity of ten tons, and is constructed of half-inch wrought-iron plates. The worm, *h*, is a coil of two-inch pipe. The boiler, *i*, is of twenty horse-power nominal, and must be placed where it will be impossible for bisulphide vapors to find their way to the fire-hole. Force-pumps are required to pump the bisulphide from the store-tank, *g*, into the extracting-vats, *a*, *b*, *c*, *d*, previously charged with the sulphur mineral. When the sulphur has been completely dissolved, the solution is run into the tank, *f*, and thence pumped into the still, *e*, where, by the application of steam in the jacket, the bisulphide is evaporated, and passes into the store-tank, *g*, for future use, while the sulphur forms a deposit in the still, and is collected therefrom. When the extracting-pans have been emptied of solution, steam is let in so as to force any remaining bisulphide vapors into the worm for condensation and recovery, thus avoiding waste of bisulphide and consequent risk of fire and explosion by ignition of its dangerous vapors. The bisulphide is allowed to remain all night in contact with the charge. The diaphragm at the bottom of each extracting-vat may advantageously be covered with bagging-cloth to filter flocculent matters from the bisulphide.

For the preparation of "roll" and "flowers of" brimstone, the crude sulphur has to be again subjected to heat. The fusing apparatus (Fig. 6) generally consists of two cast-iron cylinders, *c*, measur-

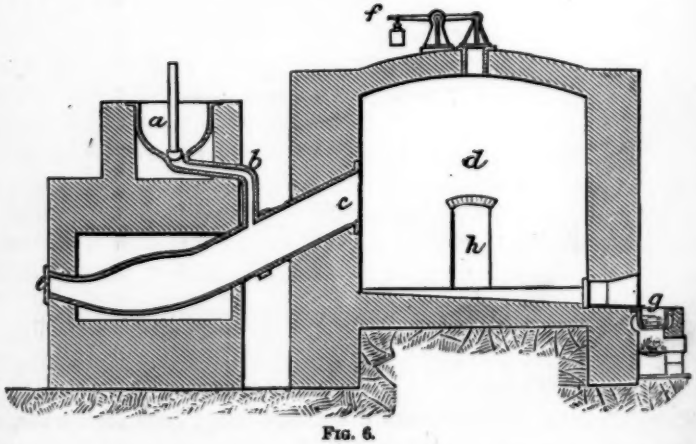


FIG. 6.

ing three feet long, by one foot in diameter, closed at one end by a door, *e*, and prolonged into a tube at the other, which leads into a brick-work condensing chamber, *d*. The retort, heated by a fire made immediately beneath, is completely surrounded by flues traversed by the heated vapors, which latter, before escaping to the chimney, heat a little pot, *a*, placed above the retort, and in direct communication

with it by means of the pipe, *b*. Into the pot, *a*, is introduced the sulphur intended for distillation. It is raised to a temperature of 257° to 302° Fahr. (125° to 150° C.), at which point the sulphur fuses, and flows, drop by drop, into the retort, *c*, where it is vaporized, and whence it passes into the chamber, *d*. The floor of this chamber is an inclined plane, converging to an aperture, *g*, by which the liquid sulphur flows out, while the "flowered" portion attaches itself to the walls of the chamber. These two forms (the liquid and the flowered) possess the same degree of purity, and their molecular difference depends only upon the varying grades of temperature under whose influence they are produced. An operation lasts about four hours. The door, *e*, facilitates the removal of spent refuse from the retort; the damper, *f*, regulates the draught and temperature in the chamber, *d*; and the door, *h*, gives access to the interior of the chamber, for the purpose of collecting the flowers of brimstone from the walls. The liquid sulphur, escaping at *g*, flows into a little pan, gently heated by a separate fire, and is thence ladled into wooden molds suspended in a bath of cold water to form the so-called "roll" or "stick" brimstone.—*Abridged from the Journal of the Society of Arts.*

PHYSICAL TRAINING OF GIRLS.

By LUCY M. HALL, M. D.

AN eminent French writer has said, "When you educate a boy, you *perhaps* educate a man; but, when you educate a girl, you are laying the foundation for the education of a family." He might have added that to this end the physical training was of equal importance with the mental.

In these days the subject of the physical training of young men is occupying much attention, and the discussions are broad and full of interest. The fault is, that the needs of both sexes in this respect are not equally considered.

An erect figure, an organism in which the processes of life may go on without the ceaseless discord of functions at war with each other because of abnormal relations—in short, the added advantages which a fine physical adjustment gives to its possessor—are as necessary to one sex as to the other, and for the same reasons.

If physical education and consequent improvement are things to be desired, it is not that a number of individuals as a result of this training shall be able to perform certain feats of strength or agility, but in its broadest sense it is for the improvement of the race, and the race can not materially advance physically, intellectually, or morally unless the two factors which constitute the race share equally in what-

ever tends to its greater perfection. Therefore, if in consequence of proper physical training men can do more work, live longer, and transmit to their offspring a share of this improved condition, women also should be so trained that they can do more work, live longer, and contribute to the higher possibilities of their offspring by supplementing instead of thwarting the promise which has been presupposed in the higher development of the male parent.

The question of the varieties and degree of exercise adapted to young women, and the many theories unsupported by observation which have been advanced, have done much to discourage the efforts and hinder the progress of those who have been honestly endeavoring to establish a reform from which definite results might be determined. The growing recognition of the necessity for thorough work in this direction is the lever which must in time remove all obstacles that have thus far stood in our way.

Professor D. A. Sargent, M. D., of Harvard College, a gentleman who has much practical experience in these matters, writes with regard to his observations in many of our female colleges and seminaries, "They all feel the demand for improvement in this direction, but for the most part their efforts are lame and impotent." He does not attribute this to lack of ability to come up to the required standards, but says that a need of encouragement and of suitable equipments exists.

Although I have been refused any statistical information, upon the plea that it was too early to make a summary of results, I know that in a few of the colleges for women the work of the drill-room is done with precision, and, what is better, enthusiasm. The late physician of one of these writes: "I am inclined to regard properly-conducted gymnastic exercises as decidedly beneficial to female students. There has been in some instances less headache, in others marked improvement where various disturbances to health had existed. I look for benefit to all students who practice regularly and faithfully. It strengthens more sets of muscles than walking or rowing; the latter takes them into the open air. They need both, in order to do the best work."

A lady, lately connected with a famous English college, writes that gymnastic exercises were employed, but were not so popular as walking, horseback-riding, and tennis. She adds, "Walks of fifteen or twenty miles were not so unusual as to excite remark," and mentions two friends who "did" thirty miles in a day without fatigue. "Indeed, one of them spent the entire evening afterward in dancing."

These facts certainly indicate that women are not by nature lacking in physical resources. The question, then, arises, What are the best methods of developing these resources?

It is a well-known fact that in women the vital grasp, tenacity of life, if we may so term it, is stronger than it is in man. This is perhaps a necessary provision, because of the added fact that through the

physiological processes of her being she is exposed to greater perils than are her stronger brothers. The existence of these conditions also renders her more liable to injury from any sudden and severe muscular strain, against which the system has not been fortified by previous training.

Some one has said that, in order to improve the health of the present generation, it would be necessary to correct the hygiene of our grandmothers! It is to be regretted that we can not begin thus early; but we can improve the grandmothers of the future by beginning with the young girls of to-day, and, through a sustained and systematic course of culture, help them to reach maturity with a physical endowment which will enable them more successfully to take their part in the battle of life. I would therefore say, begin the training early; where this is not possible, begin carefully.

Regulated gymnastic exercise is only one means of physical culture: modes of dress, out-of-door exercise, bathing, sleeping, the plays of young children, all are of equal importance.

If the little girl is to be reared with a view to perfect physical development, she should be dressed in as substantial clothing as her brother, and all trimmings and accessories necessitating extra care and stimulating a tendency to self-consciousness and the impression of sex should be avoided. If the boy is provided with a bicycle, the girl should be given a tricyle, and so with all the inducements by which he is stimulated to seek recreation in the open air. She should share them.

If, from the exuberance of health and vitality which this course engenders, the girl should chance to make as much noise as a boy, she should not be checked and repressed, while he is sent out-of-doors to have his frolic out. Above all, should the following of that routine custom in the education of girls, piano-practice, be avoided. The piano is the family vampire, which has sapped the vitality of thousands of young girls by keeping them from the healthful recreation and exercise which they so much need. It should be a rule of every educator that no girl should be allowed to take a course of music-lessons while she is pursuing the regular routine of her school-work.

As the girl approaches womanhood, let it be remembered that the need of healthful *mental* work is never greater than now. Muscle and nerve and intellect do not develop and grow strong upon sensational literature and fancy-work, and this is why girls at this age often grow morbid, sentimental, and self-conscious. Those instincts which should be kept in abeyance are stimulated into activity, and nervous, hysterical, or chlorotic conditions result.

Where the mind has been healthily directed, the system fortified by unstinted out-of-door recreation, and the muscles trained to endure prolonged effort without fatigue, the above conditions will be looked for in vain.

Walking, running, horseback-riding, tricycle-riding, lawn tennis,

swimming, rowing, skating, bowling, hand-ball, and general gymnastics, are the exercises best adapted to girls, and, for that matter, to any persons who wish a healthful and well-balanced rather than an abnormal physical development.

(The harmful and disfiguring accidents which often result from the rougher games practiced by young men, as well as the graver injuries which are the direct result of heavy lifting or a sudden severe strain upon certain sets of muscles, are matters to be deprecated, not emulated, and perfect physical training does not require such sacrifices.)

Where the girl has been allowed to grow to early womanhood neglectful of the requirements for proper physical culture, the question of what she may then undertake is a more serious one. If she be in college, the college physician should ascertain if there are any organic defects, and, if any exist, regulate her exercise in accordance with the requirements of the case. In nearly all cases, if the work is begun carefully, increased gradually, and sustained systematically, the best results will follow.

Let the girl be properly reared, and it will be found that Nature has imposed no obstacles against the attainment of the most healthful and highest physical standards which are commensurate with the normal development of the system.

FIELD EXPERIMENTS IN AGRICULTURE.

By H. P. ARMSBY,

PROFESSOR OF AGRICULTURAL CHEMISTRY IN THE UNIVERSITY OF WISCONSIN.

THE field experiment is both the oldest, the most common, and the most popular form of agricultural experiment. So soon as agriculture passed beyond the rudest and most primitive stages, the idea of testing the value of different manures, or of different modes of culture and treatment, or of divers kinds or varieties of plants by means of comparative trials on adjacent plots of ground, must have suggested itself, and so the agricultural field experiment was initiated. In its beginning it must have been of the rudest character, and yet the fundamental idea was essentially scientific, viz., to place the things to be compared under the same conditions, and let each bring forth its results; and while the details of such experiments have been gradually refined, and errors of method eliminated, they are still the same in purpose and essence.

Such experiments appeal powerfully to popular interest; and the reasons for this are not difficult to perceive. Field trials deal with subjects of constant and absorbing interest to the farmer in a way readily comprehended; they employ processes with which he is familiar through daily use of them; above all, they seem to promise results

directly applicable to practice. It is not to be wondered at, then, that in a time when agricultural experimentation is attracting attention as never before, field experiments should be multiplied on every hand, and that the public should regard the making of them as one of the chief ends, if not the chief end, of experiment stations and experimental farms. Both in Europe and America a vast deal of time and money has been devoted to their execution, and not only have organizations undertaken them, but private farmers have been urged to experiment on their own farms, both with a view to obtaining a better knowledge of the needs and capacities of their soils, and in the hope of advancing the science of agriculture.

The literature of the subject is voluminous, particularly in relation to the use of manures and fertilizers, and it might be expected that by this time our knowledge of these matters would be tolerably complete.

When, however, we come to look for the results of all this work, we find them surprisingly meager in comparison with the expenditure of time and labor which they have cost. That many valuable results have been reached goes without saying; but relatively their number is small, while the number of uncertainties and contradictions is remarkably great. The weakest portion of agricultural chemistry is that relating to fertilizers and manures; that is, precisely that part which we should expect to find well developed.

This state of affairs could not fail to impress thoughtful students of agricultural science, and cause them to seek out the reason why a method, which is apparently based upon a correct principle, and which has been executed with so much labor and care, has yielded, on the whole, such unsatisfactory returns.

Quite recently two German investigators, Professor Paul Wagner in Darmstadt, and Professor G. Drechsler in Göttingen, have given especial attention to this question, and have reached some interesting and important results, a brief account of which may not be uninstructive at a time when such general attention is being given to agricultural experimentation. These two experimenters have worked quite independently of each other, and their substantial agreement is strong evidence of the correctness of their conclusions.

We have said that the fundamental idea of the field experiment is essentially scientific; but, while this is true, a more critical examination shows that the way in which this idea has been carried into execution has been far from scientific. The scientific method of experiment requires two things: 1. All the conditions of the experiment must be identical, with the exception of the one whose action is to be tested, and that must vary to a known extent. 2. The limits of error of the methods of weighing, measuring, etc., used, must be known, to the end that we may know whether any difference which may be observed is accidental or significant.

The field experiment, as commonly executed, has sinned against both these requirements, but particularly the first, in that it has *assumed* uniformity of conditions instead of *proving* it. One of the most important of these conditions is the soil. It has too frequently been assumed that simple inspection is sufficient to assure one of the uniformity of this factor, but this is far from being the case.

Uniformity of soil over any considerable area is by no means an easy thing to attain. In our Northern States, or in any drift-region, one has only to examine the sides of the nearest ditch in order to convince himself that the character of the soil varies from rod to rod, and almost from foot to foot, and to cause serious doubts as to the value of comparative field trials to arise in his mind. But even in localities where such striking variations do not occur, sufficient differences between adjacent plots are frequently found to invalidate the results of such trials. These are not only differences in the amount of available plant-food present; the physical properties of the soil play a prominent *rôle*. Even slight differences in the depth or texture of soil or subsoil, a greater or less proportion of organic matter, a difference in surface color, a variation in the moisture of the soil, may have a decided effect on the crop. Repeated trials have shown that it is practically impossible to prepare a series of plots whose natural crop-producing power shall be uniform.

Under these circumstances trustworthy results in field trials can be expected only if the amount of probable variation between different plots is known. A preliminary cropping without manure naturally suggests itself as adapted to furnish this information, and such preliminary trials are of great value. At the same time they are not of themselves sufficient. A different season may cause the relative yield of two plots to vary considerably in different years. Moreover, two plots might show the same yield when unmanured, and yet be differently affected by the same manuring. As a control on the natural variation of the soil, Drechsler depends chiefly upon duplication of manurings, the same treatment being applied to a number of plots scattered over the field. By this he aims to accomplish two things: 1. The average yield of these several plots is more likely to correspond to the response which the field as a whole would make to the same manuring than is the yield of any single plot. 2. The variations of the several plots from the average furnish a measure of the uniformity of the soil, and serve to show whether a given difference in the final results of two kinds of manuring is significant, or is simply accidental and less than the errors of experiment. This is not the place to enter into a description of all the precautions required in the conduct of such trials. Those interested can consult Drechsler's original papers. One point may be noted, however, viz., that differences in the season, whether wet or dry, e. g., may have a deciding influence on the action of manures, and that only continuing the experiments for a number of

years can eliminate this source of uncertainty in the interpretation of the results.

As regards the practicability of the method of exact field experiments as developed by Drechsler, it is worthy of remark that, while results which conform to its criteria are trustworthy, a considerable proportion of his own experiments have simply succeeded in demonstrating that the soil was too unequal to admit of successful field trials.

Wagner has attacked the problem in a different way His first attempt was to make field experiments upon very small plots, only two or three square metres in area, separated from each other by walls of masonry, and to compensate for the small size of the plots by the care with which they were treated. He also adopted the plan of repeating each manuring several times, as described above. The results were not satisfactory, however, owing largely to the unequal distribution of water among the plots, and after numerous experiments he has abandoned this method and adopted that of pot experiments. His pots are cylindrical zinc vessels, fifty centimetres (nineteen inches and a half) high and twenty-five centimetres (nine inches and three quarters) in diameter. These are uniformly filled with the carefully mixed soil, and are provided with an arrangement by which the water of the soil is automatically replaced as fast as it evaporates. The small size of the pots permits the use of pure materials as fertilizers, while for the same reason duplicate trials can easily be multiplied. The method in Wagner's hands has proved a practical one, and has already yielded some very interesting results.

It may seem that such a method as this is too far removed from the conditions of actual practice to afford results of any practical value. There is a degree of truth in this criticism. The conditions in such an experiment are different from those in the field. Wagner's method has one inestimable advantage, however, viz., that all the conditions of the experiment are under control. The importance of this is strikingly shown by considering the effects of a deficient supply of water, such as is liable to occur in any field experiment.

It is a well-known law of vegetable growth that that factor which is present in the least quantity in comparison to the amount needed—i. e., which is present in relatively the minimum quantity—is the one which chiefly regulates the amount of production. If, in a field trial, the supply of water holds this position, as it easily may, it and not the diverse manuring will determine the amount of crop. Moreover, as the plants grow larger and expose more leaf-surface, they exhale more water, and it might very well happen that a supply of water which was sufficient for a plot lightly manured might not be enough to supply the exhalation from the more luxuriant plants on a better-manured plot. The result would be, that the growth on the latter plot would be hindered, and the manure would not have a chance to show its full value. In pot experiments conducted according to Wagner's plan,

such a case could not arise, the water-supply being uniform and in excess of the needs of the plants. The same considerations apply to other conditions, of course, though less markedly than to the water-supply. In carefully conducted pot experiments it is possible to have practically all the conditions controllable, while duplicate trials will show the degree of accuracy obtained.

What, now, is the value of this method, as compared with properly conducted field experiments, in the study of agricultural questions? Can it replace them either partially or wholly? An intelligent reply to these questions must distinguish between the various kinds of problems which present themselves for solution.

In the first place, many purely scientific problems demand attention. These are of the first importance, for, until we can master them, all attempts to apply science to practice will have but partial and uncertain success. Such problems are, for example, the most suitable form in which certain fertilizing substances may be applied (sulphate or chloride of potassium, nitrates or ammonium salts, soluble or reverted phosphoric acid, etc.), the effect of differing degrees of fineness, or of a more or less uniform distribution at different depths in the soil, the effect of different manurings upon the chemical composition and feeding value of the plants produced, the specific needs of different plants as regards fertilizers, etc., etc.

Such problems as these can be solved only by scientific methods of experiment, in which all the conditions are under control. Just as the question, what substances are essential to plant-growth, was not solved by field experiments, but by the method of water-culture, in which no soil at all is used, so questions such as were just mentioned seem likely to reach their solution by a method almost equally removed from the conditions of practice. But while the method of pot experiments appears well adapted to resolve scientific questions, and while its results (if reached legitimately, and tested carefully) are true independently of any extraneous considerations, those results need to be tested under actual working conditions; not as to their truth—that is settled—but as to their applicability to practice. It is true, as a scientific fact, that certain varieties of feldspar contain several per cent of potash, and it is also true that potash is an indispensable element of plant-food; but he who should therefore try to supply potash to his crops by means of ground feldspar, would be likely to meet with very indifferent success. He would not thereby *disprove* the fact that feldspar contains potash, or that potash is indispensable to plants. He would simply show that to these two facts there must be added some information as to the availability of feldspathic potash as plant-food, and so his field experiment would be the starting-point of a new series of scientific investigations, which should show whether the first-named facts were capable of any useful application.

The method of exact field experiments, then, as developed by

Drechsler, has for its proper object the testing of facts obtained by pot experiments or by other scientific methods, as to their direct applicability to practice. It can never be a means of investigation itself, but it is indispensable to a proper utilization of the results of investigation, as well as in suggesting new directions for research. For these purposes it can not be too exact, and it would be well if those who are called to the conduct of such experiments would make themselves thoroughly acquainted with the difficulty of obtaining results which will endure careful criticism, and with the almost numberless precautions necessary thereto.

Other and ruder forms of the field experiment are omitted here. They are, or may be, of much practical value when carefully made and rightly interpreted, but their contributions to the *science* of agriculture are *nil.* The two methods whose general features have been described, however, are really means of scientific research. They are laborious because the subject is a difficult and complicated one, but by their conjoined aid we may hope to make sure if slow progress. The thing of prime importance is a clear recognition of the possibilities and of the limitations of each method.

CHOLERA.*

By Dr. MAX VON PETTENKOFER.

I. ITS HOME AND ITS TRAVELS.

CHOLERA is an infectious disease. By infectious diseases are meant those diseases which are caused by the reception from without of specific infective material into healthy bodies, which material acts like a poison. To the list of infectious disorders belong such different maladies as small-pox and intermittent fever. Infective material differs essentially from lifeless chemical poison in being composed of the smallest possible units of living matter which when taken into healthy bodies rapidly increase and multiply under certain conditions and by their life-growth disturb the health of the body. These germs of disease belong to the smallest units of life, to the schizomycetes, which lie on the border-land of the invisible, and which, according to their form, are known as cocci, bacteria, bacilli, vibriones and spirilla, and thirty millions of which, according to Naëgeli, hardly weigh one milligramme! Infective material is derived partly from sick individuals, in which case the disease is termed "contagious" and partly from locality (earth), in which it has developed, in which case the resulting disease is termed "miasmatic." It is obvious that when derived from both sources the resulting affection was, and even now is, designated "contagio-miasmatic." I am of the opinion that the

* Reprint of a special translation made for the London "Lancet."

"contagium" and the "miasm," which have given rise to much misunderstanding, would best be dispensed with altogether; and that the designation "infective material" (Infectionstoff), which is common to both contagium and miasm, should be divided into entogen and ectogen, according as the material is obtained from the sick body or the locality (soil). According to many, cholera would belong to the entogenous section, and according to others to the ectogenous division. The supporters of the first view might be termed "contagionists"; the supporters of the second "localists." As is always the case in medicine, the conflict of views is important, inasmuch as the measures to be adopted in the healing and prevention of a disease depend on the theoretical conception of it.

All readers know that cholera originated in the East Indies, and most individuals are also aware that the epidemic spread into Europe in the present century (1830). We shall first speak of its age in India, the home of cholera. There the disease appears to have existed at all times; not only at the time of the discovery of the sea-passage to India by the Portuguese, but long before, as the oldest Sanskrit writings show. Many hundreds of years before the birth of Christ the disease was accurately described and its epidemics spoken of as attended with *mahâ mârî* (*magna mors*, great death). In these writings the disease appears under widely different names, which are taken from the chief symptoms: 1. *Vishû dschikâ*, vomiting and sweating; 2. *Alasikâ*, cramps which bring on exhaustion and stiffness; 3. *Rilambikâ*, which is perhaps best translated by the term "collapse." Another word which is often used in India is taken from the Mahratta, *mordeshin* or *mordschi*, which has been translated into French as *mort de chien*, but which also means "collapse."

In the seventeenth and eighteenth centuries A. D. there are abundant proofs and descriptions of epidemics of this disease. The disease is best known in Europe under the names of cholera, cholera morbus, Asiatic cholera, since the epidemic of 1817 to 1819, in which the English army, under the command of the Marquis of Hastings during a war against the natives, was rendered unfit for fighting and almost annihilated. But cholera had never visited Europe till the present century, when in 1830 it appeared in Russia and spread to Poland, where war was prevailing. Since that time, sometimes at longer and sometimes at shorter intervals, cholera has appeared in Europe. The question why cholera remained a thousand years in India before it first began to migrate is one of great interest, but one which can not be satisfactorily answered. The principal consideration appears to me to be that the event happened at the time when intercommunication in all directions, both by water and land, had become more rapid. The first steamship appeared in the Indian waters at the beginning of the second decade of the present century. By land also intercourse was greatly accelerated. The Russians possibly

took cholera from India, Arabia, Afghanistan, or Persia, through couriers and stage-coaches. It soon became clear that cholera, the specific cholera-germ, was in some way or other propagated along the paths of human intercourse, and it also became evident that unless the germs found a suitable soil within a certain time they did not flourish. Observers soon discovered that cholera was more prone to appear in certain regions and to affect certain localities, while it shunned other districts; and, again, that other regions were only visited at intervals of many years. It is also a fact that Asiatic cholera never yet appeared at a place which had not previously been in communication with a region where cholera prevailed; and, further, that the disease from an infected locality never yet passed on to another place if the journey lasted a certain time without interruption. The large intercourse between India and Europe, more particularly England, by means of ships which sailed round the Cape of Good Hope, had never succeeded in carrying cholera from India to England; it was only by the overland route that cholera reached England. Neither had the Cape or Australia ever been visited by cholera. It is possible that in the future the communication may be so much accelerated that cholera may get to these countries. In much the same way South America escaped during the epidemic (1830–1840) in Europe and North America. It was supposed that in South America yellow fever was enough to prevent cholera, or that this disease kept out cholera, until suddenly, in 1854, after a service of fast sailing-vessels between Philadelphia and Rio de Janeiro had been established, the chief town in the Brazils experienced a terrible epidemic of cholera. When cholera passes overland it dies out unless it finds a suitable soil within a certain time. Rainless deserts are unfavorable to cholera. Caravans which pass from infected localities through deserts have never spread the disease, provided the journey in the desert lasted at least twenty days.

Cholera always requires for its propagation favorable stations on land, and, as a rule, if the course of epidemics be traced, a gradual extension in successive years is found to take place in fixed directions. In the east and southeast of Russia, for example, cholera prevailed after it had raged in Persia in 1868; in 1869 eleven, and in 1870 thirty-seven provinces were affected, and among them five districts in Poland. In the year 1871 the epidemic spread into the west, east, and north of Russia, and succeeded in reaching East Prussia, when Königsburg was severely visited, so that from July 24th to November 8th, 2,012 individuals died there of cholera; while in Berlin only fifty-two and in Potsdam only seventy-one succumbed. In 1872 the epidemic reached Eastern Hungary, and in the following years reaped rich harvests in Germany. It has rightly been said, therefore, that cholera does not travel quicker than man. Nevertheless, the spring-like mode of progression of cholera is noteworthy: for example, it regularly jumps from Marseilles to Paris, or *vice versa*, passing over

Lyons, the second largest town of France. Or, watching the passage over smaller distances, in 1854 it went from Munich to Augsburg by railway, leaving intact the ten intermediate stations, although several patients alighted and some even died; and, notwithstanding that cholera raged at Augsburg and Lech, it never once sprang over the valley of Lech to the town of Friedberg, which is but a league distant. Or, to take a still narrower circle, cholera thrice (1836, 1854, and 1873) invaded Munich, and every time halted in those houses situated on the clay soil in the suburbs.

The capriciousness of cholera may be observed in its relations not only to space but also to time; at one time it infected Prussia and shunned Saxony, while at another it did exactly the reverse. In the year 1849 Berlin experienced its worst epidemic, an epidemic in which Saxony was but slightly affected (488 cases) and Bavaria not more so. In the year 1850, when the cholera in Berlin and its environs had almost subsided, the epidemic raged in Saxony until 1,551 deaths occurred, though Bavaria was not involved. In 1854 the matter was altogether different; then Munich and Bavaria had its worst epidemic, at which time the Industrial Exhibition was held at Munich, and the intercourse between Munich and Saxony and the whole of Germany was very active. The cholera did not, however, spread to Saxony. All the fatal cases of cholera in Saxony had taken the disease from Munich. The epidemic did not spread farther north; yet the inhabitants of Saxony and Prussia had sufficient susceptibility for the disease, as was proved when they went to Munich. It was in the year 1855 that a change occurred; then Bavaria was exempt, and the epidemic devastated Saxony and North Germany. What relation the extension from India by the agency of man may have to conditions of time and space, to local and periodical disposition, has yet to be worked out; but the fact of the existence of relations in time and space is as undeniable as that of cholera itself. The cholera-germ alone will not explain everything. We must now inquire into the differences between places which are and those which are not susceptible, and endeavor also to trace out the relations in time which obtain in susceptible places.

No doubt can be entertained that the configuration of the earth has a certain influence. Relatively low-lying sites are very favorable to cholera. Where the surface of the earth has an undulating outline, it will be found that districts and individual houses which are situated on the summit of the undulation very frequently have no, or only a very small, disposition to the development of an epidemic of cholera, while in the hollow of the undulation under like conditions the opposite holds good. The truth of this statement is seen in single districts where parts or single houses exist on the summit and others lie low.

Another feature which is found in every epidemic is the falling off of the disease in the neighborhood of and on mountain-ranges. The Himalayan Mountains, those of Lebanon and the Alps, have always

formed the places of refuge for fugitives from cholera. Now and then an epidemic occurs in the mountains; these exceptions will be dealt with later. The immunity, or the slight susceptibility, of mountain-ranges for cholera is witnessed in India as plainly as it is in Europe. A familiar example is the complete freedom from cholera of the hill-stations along the Himalayas, in which, through frequent changes of troops, the cholera has every chance of being taken up from the plains. In the severe epidemic of 1869 there were only two cases of cholera in nineteen hill-stations. A similar experience is met with in narrower areas. For instance, in Munich, 1873–'74, the frequency of cholera was widely different in the seven barracks of the garrison. In the low-lying Isar Kaserne (occupied by cuirassiers, heavy cavalry regiment), out of one thousand men there were forty cases of cholera; in the high-lying Max II Kaserne (with two field-artillery regiments) only three cases, and this without there being any difference in the construction of the caserns, the occupation or the diet of the men, or the drinking-water. Another local factor, which is also very evident, is the nature of the soil. Where the soil is compact, and not, or very slightly, permeable for water and air, the development of cholera is much hindered. Some time ago Jameson, in his description of the epidemics of 1817 and 1819 in India, said, "Cholera does not appear to like a rocky soil." French epidemiologists (Boubée and others) have said the same thing. I studied this point in Bavaria in 1854, and then collected so many facts that I came to the conclusion that cholera requires for its epidemic development a porous soil through which air and water easily percolate, and that a compact soil was decidedly inimical. It will be sufficient to give a couple of illustrations. When the cholera broke out in Munich the inhabitants scattered themselves on the mountains. Many settled in the valleys, where several fell ill and died. The greater part of the town in which the better hotels were situated lies upon compact chalky soil, and the smaller part was built upon alluvial soil. In this part the cholera assumed an epidemic character. In the higher-lying districts (Schrödelgasse) the epidemic began in the beginning of August, and in the lower lying areas toward the end of September, while the greater part situated on chalk was not affected. Among the Jura Mountains to the left of the Donau lies a village called Kienberg, which is built on rock. In this village the cholera broke out so fiercely that within a month thirty per cent of the inhabitants died. When I went there I found many houses emptied, while other houses had not had a single case of illness. I then thought that the drinking-water was at fault. But the whole village drew water from a single spring at the foot of the slope on which the village was situated. From a study of the soil I found that all the houses built upon porous and rather loamy sand had been attacked, while those which lay upon the compact soil of the Jura rocks had escaped. The greater part of Kienberg stands upon a cleft of the

mountain which had been filled up by fine soil which had resulted from the wearing down of the higher parts of the mountain (alluvial soil). That some doubt should be thrown on the decision of the commission which had adopted my views on the influence of the natural state of the soil on cholera was not to be wondered at. I spared no pains, however, in going to the Krain and Karst Mountains, where cholera apparently was raging on a bare, rocky soil, and instead of contradiction I found a further corroboration of my views. The towns lying among these mountains were found to suffer from an affection which unquestionably proceeds from the soil—namely, ague. The mountains are freely cleft, and the clefts are filled with porous soil, allowing of the free percolation of water and air, so as to be nothing more than an alluvial soil. Here streams rush down the mountain-side, turn off at its base, and run on richer still in water. You may often find there a cleft having the shape of a funnel, filled with porous earth ; the nature of the cleft and its contained earth may be determined by sinking a so-called Dolione, when the bottom will be found to be solid stone. Through the Adelsberger growth the rapid Poik flows ; and on the other side of the mountain in which the grotto is situated the waters of the Poik roll off under the name of the Unze ; the Unze again flows off at the base of a mountain, as a navigable river, on the other side of Laybach. As I proceeded from Laybach to Novomsto (Neustadtl), I saw shining in the distance before me and far below the mountain a village, which turned out to be Rasderto, where I learned from my companion, a schoolmaster, that ague prevailed, and, indeed, I found many sufferers confined to bed from this complaint. Rasderto lies below the sites which the cholera infested. At the base of the rocky hills on which Rasderto is situated, there flows a stream which is so powerful that it turns a mill.

In order to study the cholera at Malta I proceeded thither in 1868 at my own expense. Mr. John Simon procured me the necessary introductions. On arriving in the harbor of Valetta I was forcibly struck with the rocky nature of the soil. The rocky hills rose high above the water, and on alighting on shore my feet encountered the resistance of bare rock. I ascended the steps hewed out of the solid rock, by which means I reached the plateau, on which the greater part of the town is built. A promenade, which was also shaped out of the natural rock, led me to my hotel. I now became very desirous for a further study of the place. Mr. Inglott, at that time the chief medical officer of the hospitals in Malta, and Dr. Pisani, a distinguished Maltese physician, rendered me very efficient aid in my researches. They often wondered why I had determined to visit Malta. How often did they say to me, when I questioned them on the nature of the soil of this rocky island, "Our rock is not rock in your sense of the term, but it is a sponge which sucks up everything which falls upon it"! Investigation proved that the Maltese rock was as porous

as Berlin gravel, and that more than a third of its volume consisted of air-containing pores. It is so soft that it can be cut and sawed like wood. As visitors may purchase wood-carvings from Oberammergau and Berchtesgaden, so one can obtain carved-work of Maltese stone. Tiles cut from Maltese stone find a ready sale in Italy, where they serve to decorate the floors of rooms, where, owing to their porous nature, they are not so cold to the feet as stone tiles. Maltese tiles are as good as wood without being so inflammable. Moreover, of the same stone vessels are made which English sailors use to filter their drinking-water. Turbid water when poured into such vessels filters off as a transparent fluid. It will be readily understood that I now no longer concerned myself as to an explanation when I heard that an epidemic of cholera had broken out at a place which apparently had a compact soil.

Not only does the physical nature, but also the chemical constitution, of the soil have an influence on the occurrence of cholera—to wit, the presence of organic matter and water. The influence of the soil on the development of infectious diseases can only be understood by a study of the organic processes which take place in it. The processes are eventually dependent on the action of the lowest organisms, which require for their growth a certain temperature, so much water, air, and food-stuffs. In order to explain the occurrence of cholera on such varied soils as those composed of granite, sand-chalk, and shell-chalk, we must suppose that the soil contains in its interstices much organic matter and water. Farmers know how useless pure soil is, whereas the luxuriant growth of plants when the ground is manured is well known to all. These observations are applicable to the lowest plants, the bacteria, no less than to grain and vegetables. The germs of putrefaction and fermentation abound in the free atmosphere, but they only grow and multiply where they find suitable food. The hygienic uses of cleanliness here find their explanation and scientific foundation. The refuse from houses, dissolved or suspended in water, forms an excellent nutritive material for the lowest organisms which are so harmful to us. Emmerich has shown that the purest water after being used to clean the floor of a room contains in a very short space of time abundant germs of disease, so much so that a drop of it injected under the skin of a rabbit or Guinea-pig is followed by a fatal result. With this dangerous slop-water it is the custom to charge the earth in and about our dwellings. Since man began to live in towns where drainage was in vogue, diseases dependent on conditions of soil (cholera and typhoid fever) have undergone a striking decrease. Just as a field, when excessively manured, does not always remain good for vegetation unless remanured, so is it also with the uncleanliness of the soil in the neighborhood of our houses. As soon as we cease to make unclean—to manure—so soon do our towns begin to purify themselves, just as a churchyard after a time becomes purified. In a simi-

lar fashion does good drainage act in cleansing our towns, and the necessity of a pure water-supply is thus vindicated. It is in this way that, according to my view, cleanliness acts as a deterrent to cholera. Cholera-germs may come, but they can not fructify under such circumstances. That sites naturally exist which, without human interference, are unfavorable to cholera, has already been shown.

Where water entirely fails the organic processes soon come to an end; this is true of the soil of the earth. In rainless deserts the soil is dry except the most superficial layer during the night. In such desert places no organic processes can go on; this is shown not only in the absence of vegetation, but may be proved by an investigation of the nature of the air of the soil ("Grundlutt"); this air under ordinary circumstances contains much carbonic acid, which proceeds from the processes of organic life; but where the soil is free from water the air of the soil much more closely resembles that of the atmosphere above it. This fact has been experimentally proved by Professor von Zittel by a comparison of the free atmosphere with the air of the soil of the Libyan Desert. These observations are believed to explain how it is that cholera does not appear on a very dry soil. Just as too much water is bad for certain plants, so is it also for some members of the lowest class of the vegetable kingdom. It is likewise conceivable that the organic processes in the soil on which epidemics of cholera depend may be effectually checked by an excess of subsoil-water or by a want of material. Micro-organisms have been divided into two classes: anaerobe and aerobe. If now we have to deal with an organism which requires oxygen for its existence (aerobe), it is not difficult to understand how the excess of water might deprive the soil of the necessary proportion of air. The more the pores were filled with water the less air would be contained in the soil. In heavy clay soils the water drives the air completely out, and thorough desiccation would be required to replace all the air. Klebs and Tommasi-Crudeli have already discovered a micro-organism which flourishes only in a moist soil containing air—the bacillus malariæ.

We shall now inquire into the time relations of cholera at its permanent home in Lower Bengal. Dr. John Macpherson has, in his work on "Cholera in its Home," tabulated the number of cases of death from cholera in Calcutta for each month of the year for a period of twenty-six years. I have calculated and arranged in a tabular form from these statistics the average number of deaths in each month, and contrasted each month with the average rainfall at Calcutta. (See Table I.) It will be seen how unequally distributed is the great fall of rain, which is two or three times greater than in many districts of Germany. Calcutta has a rainy season, which begins at the end of May and ends at the beginning of October. The cholera decreases from the beginning and increases again toward the end of the rainy season. It reaches its maximum during the driest and hot months

TABLE I.

Average Frequency of Cholera, and Average Rainfall (in Inches) in Calcutta.

—	Jan.	Feb.	Mar.	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Cholera.....	275	359	566	745	513	243	153	132	151	239	320	317	4013
Rain.....	0·21	0·42	1·13	2·40	4·29	10·1	13·9	14·4	10·4	4·2	0·9	0·13	62·58

(March and April), and its minimum is attained during the wettest and hot month of August, so that the curve of cholera falls while that of rain rises. The rise and fall of endemic cholera is constant, while the prevalence of cholera in its epidemic form is very variable. In the Punjaub the rain-winds (monsoons) bring with them the cholera. This apparent contradiction of the experience above mentioned may be explained by considering that the monsoons bring to the Punjaub the necessary moisture which is believed to be requisite for the development of an epidemic of cholera. Rain falls in the Punjaub at the same time as in Lower Bengal, but in smaller quantity. The average rainfall at Lahore is twenty-two inches, as compared with sixty-two inches at Calcutta; so that in Lahore for the greatest part of the year the soil is too dry for cholera. That these claims are substantial will be granted by a study of the rainfall and related circumstances in other parts of India. This is well seen at Madras, as indicated by Table II. At Madras the average rainfall is about forty-eight inches,

TABLE II.

Average Frequency of Cholera, and Average Rainfall (in Inches) in Madras.

—	Jan.	Feb.	Mar.	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Cholera.....	194	191	123	64	65	59	164	191	186	143	93	104	1577
Rain.....	0·89	0·22	0·48	0·68	2·26	1·65	3·46	4·38	4·58	10·9	12·90	5·42	47·82

and is therefore midway between those of Lahore (twenty-two inches) and Calcutta (sixty-two inches), but the quantity of rain in the several months is different. The greatest quantity of rain falls in November, and Madras is not under the influence of the southwest, but of the northeast monsoon, and the rainy season extends from July to December. As Madras lies farther south than Calcutta, and the quantity of rain is twenty-five per cent less, it is plain that the desiccation during the dry and hot season would be much greater there than in Calcutta. And this state of affairs is reflected in the vegetation. April, May, and June are like winter months; the leaves begin to fall; the verdure fades away, and the sap descends to the roots of the trees, not because of the cold, but on account of the excessive dryness. It is at this period that cholera is at its minimum. In July, when the rain begins to fall, cholera increases, and reaches it maximum in August. The rain continues, but the cholera decreases, owing to the excessive dampness of the soil; so that in November a second minimum in the number of cases of cholera is met with.

In order to inquire into the accuracy of these views, another observation, taken from India, may be cited. Places which are outside the region of endemic cholera, and which have a rainy season at the same time and of about the same amount as Calcutta, have the same amount and periodicity of cholera. Such an instance is afforded in Bombay, which is a city as large as Calcutta, and the rainy season of which depends on the southwest monsoons. In a table which shows the frequency of cholera, the rainfall, and the temperature on the average for a period of fifteen years, it is evident that in all three particulars there is a remarkable correspondence between Calcutta and Bombay. (See Table III.)

TABLE III.

Average Frequency of Cholera, Average Rainfall, and Average Temperature (in Degrees Centigrade), at Bombay.

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Cholera.....	235	213	263	295	294	278	162	93	60	76	95	163	2217
Rain.....	0·03	0·01	0·01	0·02	0·41	20·02	22·69	13·10	9·47	2·01	0·27	0·09	68·12
Temperature.	24·1°	24·7°	26·2°	29·1°	30·4°	29·1°	25·2°	25·2°	27·1°	27·2°	26·2°	24·7°	....

The temperature has been given for the reason that it brings out the fact that temperature has not much influence on the progress of cholera. That Bombay is not within the endemic area of cholera is sufficiently testified by the results of the statistics for fifteen years. During this period there were three years in which no epidemic occurred. That a whole year should pass without the occurrence of a single case of cholera in Bombay is not to be expected, when the active intercourse between it and the endemic areas is borne in mind. If the table of averages relating to Bombay be compared with that of Calcutta, the resemblance is seen to be striking. The maximum incidence of cholera is seen to occur in both in April, and the minimum is found in Calcutta in August and in Bombay in September. After this minimum the increase takes place equally in both cities. The years during which no epidemic occurred in Bombay were characterized either by too much wet or too great dryness. Thus, in the years 1852–'53, the diminished frequency of cholera followed on a period of great wetness, and that of 1860–'61 came on after a very dry season. That this dependence on the weather is really sound is shown by a study of the years immediately following the lessened intensity of cholera. The years 1853–'54 and 1861–'62 in Bombay showed the same rhythm for cholera as Calcutta; whereas, on the contrary, the year 1858–'59 in Bombay had the same abnormal rhythm as Lahore. The average number of deaths from cholera in Bombay in March was 253, in April 295, and in May 294. In June, when the monsoons begin, the number further diminishes. The number of deaths in March, 1859, was 9, in April 7, in May 69, and, when in June the monsoons set in and 26·8 inches of rain fell, the number rose to 843, while the mean for June

was only 278. After dry weather Bombay also shows, like Lahore, "monsoon cholera."

Cholera in India, as is well known, has likewise a remarkable relation in time to the years of drought in India. If rain once fail, or be very small in amount, a famine necessarily follows. Distress is then felt both in Lower Bengal and in the Punjaub, but the cholera only appears more severely in Lower Bengal and avoids altogether the Punjaub. The dependence of epidemics of cholera on the time of the year (i. e., on the moisture of the soil) comes out well in countries outside India, as, for example, in Germany. In the kingdom of Prussia from 1848 to 1860 cholera was prevalent every year, though its incidence varied in intensity and in different provinces. During this period cholera was as much at home in Prussia as in India. Brauser has collated the cases of death from cholera week by week for the thirteen years, 1848 to 1860. The numbers for the different months are as follows: April, 112; May, 446; June, 4,392; July, 8,480; August, 33,640; September, 56,561; October, 35,271; November, 17,530; December, 7,254; January, 2,317; February, 842; March, 214. The numbers are founded on statistics, and it is proper to investigate the possibility of errors therein. No objection can be made to the Prussian statistics, for the numbers are too great to be vitiated by casual error. In India the statistics may not be so trustworthy, because registration is sometimes defective. Some cases of death from cholera may not appear as such, and perhaps some deaths may be falsely registered as due to cholera. The Indian statistics have, therefore, only been given for large cities, where more attention is paid to correct registration. The errors which may occur extend over all the months of the year, and are scattered, so there is less liability to perversion of the truth. And there is no need to prove absolute numbers, for relative statistics are sufficient. Further, in the garrisons and prisons of India, where physicians abound, the statistics are nearly as good as in Germany, since cholera is a disease so easily recognized. That a large series of numbers is able to eliminate to the vanishing-point the unavoidable errors of statistics is shown by an instructive example of the statistics of typhoid fever in Munich. Buhl, in studying the relations between the occurrence of typhoid fever and the state of the subsoil-water, made use only of figures obtained from the general hospital during the years 1856 to 1864, where every diagnosis was confirmed or overthrown by *post-mortem* examination. [Pettenkofer here devotes considerable space to the discussion of the question, dealing chiefly with the possible inconsistencies in the certificated causes of death. He seems to prove that the difference between the numbers gained by actual observation and those obtained by calculation is so small that it may be disregarded.] It is considered that since the rate of death from typhoid fever in the general hospital is on the above showing a fair representative of the death-rate in the

town of Munich, so the numbers concerning cholera obtained from the barracks and prisons of India may be taken as a good sample of the rate of mortality from cholera in the cities themselves. Bryden has given support, in his work on the time and space distribution of cholera in India, to the reports of barracks and prisons. That cholera should attain its greatest frequency in North Germany during the months of August, September, and October, and that winter should seldom see an epidemic, may be explained by the temperature which prevails in the air and earth. In the class of ectogenous infectious diseases, to which cholera belongs, the temperature, as in all organic processes, has a decided, though it can not be the chief, influence. That cholera is not very dependent on temperature is evidenced by the possibility of the occurrence of an epidemic of cholera during the winter. Why cholera spreads more during the summer and early autumn, as compared with winter and spring, must depend on other causes than temperature.

It is clear, in my opinion, that the soil and the moisture of the soil play a principal part. The dampness of the soil is, under certain conditions, clearly related to the subsoil-water, "Grundwasser." Epidemics of cholera abound during the time that the "Grundwasser" is falling, when the earth is comparatively dry. By "Grundwasser" is to be understood that condition of dampness of a porous soil when all the pores are filled with water. If water and air together fill up the interstices, then the soil is called simply damp. I have so long and so often spoken on the influence of the rise and fall of the ground-water on the frequency of typhoid fever and cholera, that I imagine a great many scientists credit me with the view that subsoil-water is highly harmful. But such is not the case. The subsoil-water is merely an indication of what is going on, and has no more to do with the actual processes than a dial and the hands have in the going of a clock. The fall of the ground-water by pumping away, or the rise of ground-water by the damming of a stream, has not the least effect on typhoid fever or cholera in the neighborhood. The observation of the level of the surface of the water in springs as an indication of the state of the subsoil-water is of no value from an etiological point of view, unless the spring be independent of the nearest water-course, and unless at the time of the observation the real state of the spring is a true reflex of the condition of the subsoil-water in its neighborhood. When the information, however, is obtained properly from springs free from objection, then the condition of the ground-water gives the state of moisture and of exchange in the overlying layers much more accurately than an observation made on the atmospheric downfall (rain and dew). Rain may fall for a week without causing any rise in the subsoil-water, and again a rise may occur when there has been no fall of rain for some time. The perusal of Professor Franz Hofmann's work, published in the "Archives of Hygiene," on the movement of subsoil-water

may be safely recommended. When an epidemic of cholera occurs in winter, then a relatively low state of the ground-water is found to prevail. In Munich three epidemics prevailed during the cold months: the first occurred between October and March, 1836–'37; the second from July to November, 1853–'54; and the third from July till April, 1873–'74. All three epidemics were associated with a relatively dry state of the earth, as was proved also by meteorological data concerning the rainfall. No investigation has been made as to the state of the ground-water during the period 1836 to 1854, but this investigation was first begun in 1856, so that for 1873 and 1874 the data were available; and it is only on the assumption that the condition of the soil as regards moisture was abnormal for the time of year that the long duration and strange division of the last epidemic could be accounted for. The subsoil-water sank from the end of June, 1873, till the beginning of August. On that occasion the germs of cholera probably came from Vienna, where the epidemic had prevailed since April. Two cases coming from Vienna, one in June, the other in July, could be vouched for. At the end of July the first illness from cholera occurred in Munich, but in individuals who had never come in direct contact with the infective cases. In every fresh outbreak, in 1836, in 1854, and in 1873, the same part (the northeast) of the town was the first to suffer. As the epidemics of 1854 and of 1873 developed at the same time of the year (the end of July), so by the middle of August the height of the epidemic was reached; it then fell off rapidly during September; during the whole of October only isolated cases occurred; and by the middle of November the epidemic had ceased in the higher lying parts of the town. It was thought that the disease had become extinct, and notwithstanding that it was considered strange that the summer epidemic had chiefly fallen upon the higher lying parts of the town, while the lower lying districts on this occasion had been altogether spared. In the middle of November, when the weather became colder, the epidemic reappeared, and attacked chiefly those lower lying districts which had escaped in the summer. It is impossible to trace the progress of contagion in time and space from one individual to another. The contagionists can not maintain that the unexpected falling off of cholera was due to the protection afforded by the previous prevalence of the disease, seeing that the lower lying districts had escaped the epidemic, and that the other inhabitants two months later suddenly lost their protection. Any one who studies the movements of the ground-water in Munich for the year in question will find that in the first half of August an event occurred which in suddenness and unexpectedness rivaled the retrogression of the epidemic in the second half of August. In the first half of this month there fell an abnormally large quantity of rain (one hundred and seventy-one millimetres), which excessive rainfall was the largest amount ever registered since the observations had been begun. The consequent wetness

of the soil was reflected in a great abnormal rise in the ground-water. But from August onward through the winter, and till the beginning of the year, the amount of rain and dew which fell was again far below the average, and the ground-water steadily decreased. In the middle of April, 1874, it again began to rise, and then the epidemic of cholera ceased. The abnormal fall of rain in August, 1873, in Munich had the same effect on the cholera there as the southwest monsoons regularly have on the disease in Calcutta. In the relative dryness which follows this excessive wetness the epidemic process is continued as a winter invasion.

Munich and Augsburg are very much alike in situation and in meteorological factors. Both places lie in a direct line not sixty kilometres apart. But that differences in the amount of rainfall may occur is proved by the year of cholera 1873. In Munich, in spite of the excessive fall, the amount for the whole year was hardly up to the average; in Augsburg the excess above the average was thirty per cent. In 1873 the rainfall at Augsburg approached to that of the average at Salzburg. The distribution of the rainfall was different in Augsburg as contrasted with Munich, and the same difference in the history of the cholera holds good of the two towns. Augsburg had an epidemic of cholera in 1854, but none in 1836 or 1873, when only a few isolated cases occurred. That Augsburg in place and time and in individual disposition is susceptible of an epidemic of cholera was seen in the year 1854, when about three per cent of the whole population was destroyed by the malady, while Munich lost that year but two and a half per cent. If the appearance of cholera in the two places mentioned differed only in the time required for the transit from one city to another, then the germs of cholera must pass either from Munich to Augsburg or *vice versa*. In the year 1836 Augsburg remained free from cholera, which infested Munich for six months. At that period no observations on the rainfall were made, but no doubt exists that cases of cholera passed, without isolation or disinfection, from Munich to Augsburg. These facts prove that cholera is a miasmatic disease, and may be wholly independent of human intercourse. For the year 1854 meteorological data are obtainable, and this year had as dry a season in Augsburg as in Munich, while at both places cholera prevailed. In the year 1873 the case was different. Then there were in Augsburg regulations for the prevention of the spread of cholera, without which precautions, be it noted, in 1836, Augsburg remained free from the disease. Nevertheless, cholera did not visit Augsburg in 1873, during which period stringent measures of prevention were also in full force at Munich. Such considerations lead to the logical conclusion that what saved Augsburg did not relieve Munich. Further, Munich remained free from visitation in the humid summer of 1866, when cholera prevailed in North Germany; so that no importation of cholera to Munich took place from the seat of war.

THE CHEMISTRY OF COOKERY.

By W. MATTIEU WILLIAMS.

XLIV.—THE COOKERY OF WINE (*continued*).

THE paternal tenderness with which wine is regarded, both by its producers and consumers, is amusing. They speak of it as being "sick," describe its "diseases" and their remedies as though it were a sentient being; and its diseases, like our own, are now attributed to bacilli, bacteria, or other microbia.

Pasteur, who has worked out this question of the origin of diseases in wine as he is so well known to have done in animals, recommends (in papers read before the French Academy in May and August, 1865) that these microbia be "killed" by filling the bottles close up to the cork, which is thrust in just with sufficient firmness to allow the wine on expanding to force it out a little, but not entirely, thus preventing any air from entering the bottle. The bottles are then placed in a chamber heated to temperatures ranging from 45° to 100° C. (113° to 212° Fahr.), where they remain for an hour or two. They are then set aside, allowed to cool, and the cork driven in. It is said that this treatment kills the microbia, gives to the wine an increased bouquet and improved color—in fact, ages it considerably. Both old and new wines may be thus treated.

I simply state this on the authority of Pasteur, having made no direct experiments or observations on these diseases, which he describes as resulting in acetification, ropiness, bitterness, and decay or decomposition.

There is, however, another kind of sickness which I have studied, both experimentally and theoretically. I refer to the temporary sickness which sometimes occurs to rich wines when they are moved from one cellar to another, and to wines when newly exported from their native climate to our own. The wines that are the most subject to such sickness are those that are the most genuine—the natural, unsophisticated wines, those that have not been subjected to "fortification," to "vinage," to "plastering," "sulphuring," etc.—processes of cookery to be presently described.

This sickness shows itself by the wine becoming turbid, or opalescent, then throwing down either a crust or a loose, troublesome sediment.

Those of my readers who are sufficiently interested in this subject to care to study it practically should make the following experiment:

Dissolve in distilled water, or, better, in water slightly acidulated with hydrochloric acid, as much cream of tartar as will saturate it. This is best done by heating the water, agitating an excess of cream of tartar in it, then allowing the water to cool, the excess of salt to

subside, and pouring off the clear solution. Now add to this solution, while quite clear and bright, a little clear brandy, whisky, or other spirit, and mix them by shaking. The solution will become "sick," like the wine. Why is this?

It depends upon the fact that the bitartrate of potash, or cream of tartar, is soluble to some extent in water, but almost insoluble in alcohol. In a mixture of alcohol-and-water its solubility is intermediate —the more alcohol the smaller the quantity that can be held in solution (hydrochloric and most other acids, excepting tartaric, increase its solubility in water). Thus, if we have a saturated solution of this salt either in pure water or acidulated water or wine, the addition of alcohol throws some of it down in solid form, and this makes the solution sick, or turbid. When pure water or acidulated water is used, as in the above-described experiment, crystals of the salt are freely formed, and fall down readily; but with a complex liquid like wine, containing saccharine and mucilaginous matter, the precipitation takes place very slowly; the particles are excessively minute, and become entangled with the mucilage, etc., and thus remain suspended for a long time, maintaining the turbidity accordingly.

Now, this bitartrate of potash is the characteristic natural salt of the grape, and its unfermented juice is saturated with it. As fermentation proceeds, and the sugar of the grape-juice is converted into alcohol, the capacity of the juice for holding the salt in solution diminishes, and it is gradually thrown down. But it does not fall alone. It carries with it some of the coloring and extractive matter of the grape-juice. This precipitate, in its crude state called *argol*, or *roher Weinstein*, is the source from which we obtain the tartaric acid of commerce, the cream of tartar, and other salts of tartaric acid.

Now let us suppose that we have a natural, unsophisticated wine. It is evident that it is saturated with the tartrate, since only so much argol was thrown down during fermentation as it was unable to retain. It is further evident that if such a wine has not been exhaustively fermented, i. e., still contains some of the original grape-sugar, and, if any further fermentation of this sugar takes place, the capacity of the mixture for holding the tartrate in solution becomes diminished, and a further precipitation must occur. This precipitation will come down very slowly, will consist not merely of pure crystals of cream of tartar, but of minute particles carrying with it some coloring-matter, extractives, etc., and thus spoiling the brilliancy of the wine, making it more or less turbid.

But this is not all. Boiling water dissolves $\frac{1}{8}$ of its weight of cream of tartar, cold water only $\frac{1}{180}$, and, at intermediate temperatures, intermediate quantities. Therefore, if we lower the temperature of a saturated solution, precipitation occurs. Hence, the sickening of wine due to change of cellars or change of climate, even when no further fermentation occurs. The lighter the wine, i. e., the less alcohol it con-

tains naturally, the more tartrate it contains, and the greater the liability to this source of sickness.

This, then, is the temporary sickness to which I have referred. I have proved the truth of this theory by filtering such sickened wine through laboratory filtering paper, thereby rendering it transparent, and obtaining on the paper all the guilty disturbing matter. I found it to be a kind of argol, but containing a much larger proportion of extractive and coloring matter, and a smaller proportion of tartrate, than the argol of commerce. I operated upon rich new Catalan wine.

This brings me at once to the source or origin of a sort of wine-cookery by no means so legitimate as the Pasteuring already described, as it frequently amounts to serious adulteration.

The wine-merchants are here the victims of their customers, who demand an amount of transparency that is simply impossible as a permanent condition of unsophisticated grape-wine. To anybody who has any knowledge of the chemistry of wine, nothing can be more ludicrous than the antics of the pretending connoisseur of wine who holds his glass up to the light, shuts one eye (even at the stage before double vision commences), and admires the brilliancy of the liquid, this very brilliancy being, in nineteen samples out of twenty, the evidence of adulteration, cookery, or sophistication of some kind. Genuine wine made from pure grape-juice without chemical manipulation is a liquid that is never reliably clear, for the reasons above stated. Partial precipitation, sufficient to produce opalescence, is continually taking place, and therefore the brilliancy demanded is obtained by substituting the natural and wholesome tartrate by salts of mineral acids, and even by the free mineral acid itself. At one time I deemed this latter adulteration impossible, but have been convinced by direct examination of samples of *high-priced* (mark this, not *cheap*) dry sherries that they contained free sulphuric and sulphurous acid.

The action of this free mineral acid on the wine will be understood by what I have already explained concerning the solubility of the bitartrate of potash. This solubility is greatly increased by a little of such acid, and therefore the transparency of the wine is by such addition rendered stable, unaffected by changes of temperature.

But what is the effect of such mineral acid on the drinker of the wine? If he is in any degree predisposed to gout, rheumatism, stone, or any of the lithic-acid diseases, his life is sacrificed, with preceding tortures of the most horrible kind. It has been stated, and probably with truth, that the late Emperor Napoleon III drank dry sherry, and was a martyr of this kind. I repeat emphatically that high-priced dry sherries are far worse than cheap Marsala, both as regards the quantity they contain of sulphates and free acid.

Anybody who doubts this may convince himself by simply purchasing a little chloride of barium, dissolving it in distilled water, and adding to the sample of wine to be tested a few drops of this solution.

Pure wine, containing its full supply of natural tartrate, will become cloudy to a small extent, and gradually. A small precipitate will be formed by the tartrate. The wine that contains either free sulphuric acid or any of its compounds will yield *immediately* a copious white precipitate like chalk, but much more dense. This is sulphate of baryta. The experiment may be made in a common wine-glass, but better in a cylindrical test-tube, as, by using in this a fixed quantity in each experiment, a rough notion of the relative quantity of sulphate may be formed by the depth of the white layer after all has come down. To determine this *accurately*, the wine, after applying the test, should be filtered through proper filtering-paper, and the precipitate and paper burned in a platinum or porcelain crucible and then weighed; but this demands apparatus not always available, and some technical skill. The simple demonstration of the copious precipitation is instructive, and those of my readers who are practical chemists, but have not yet applied this test to such wines, will be astonished, as I was, at the amount of precipitation.

I may add that my first experience was upon a sample of dry sherry, brought to me by a friend who bought his wine of a most respectable wine-merchant, and paid a high price for it, but found that it disagreed with him; since that I have tested scores of samples, some of the finest in the market, sent to me by a thoroughly conscientious importer as the best he could obtain, and these contained sulphate of potash instead of bitartrate.

My friend, the sherry-merchant, could not account for it, though he was most anxious to do so. This was about three years ago. By dint of inquiry and cross-examination of experts in the wine-trade, I have, I believe, discovered the origin of the sulphate of potash that is contained in the samples that the British wine-merchant sells as he buys, and conscientiously believes to be pure. I will state particulars in my next.

XLV.—COCOA AND THE COOKERY OF WINE.

A correspondent writes to the editor asking whether I class cocoa among the stimulants. So far as I am able to learn, it should not be so classed, but I can not speak absolutely. Mere chemistry supplies no answer to this question. It is purely a physiological subject, to be studied by observation of effects. Such observations may be made by anybody whose system has not become "tolerant" of the substance in question. My own experience of cocoa in all its forms is that it is not stimulating in any sensible degree. I have acquired no habit of using it, and yet I can enjoy a rich cup or bowl of cocoa or chocolate just before bed-time without losing any sleep. When I am occasionally betrayed into taking a late cup of coffee or tea, I repent it for some hours after going to bed. My inquiries among other people, who are not under the influence of that most powerful of all arguments, the logic of inclination, have confirmed my own experience.

I should, however, add that some authorities have attributed exhilarating properties to the *theobromine* or nitrogenous alkaloid of cocoa. Its composition nearly resembles that of theine, as the following (from Johnstone) shows :

	Theine.	Theobromine.
Carbon	49·80	46·43
Hydrogen	5·08	4·20
Nitrogen	28·83	35·85
Oxygen	16·29	13·52
Total	100·000	100·000

It exists in the cocoa-bean in about the same proportion as the theine in tea, but in making a cup of cocoa we use a much greater weight of cocoa than of tea in a cup of tea. If, therefore, the properties of theobromine were similar to those of theine, we should feel the stimulating effects much more decidedly.

The alkaloid of tea and coffee in its pure state has been administered to animals, and found to produce paralysis, but I am not aware that theobromine has acted similarly.

Another essential difference between cocoa and tea or coffee is that cocoa is, strictly speaking, a food. We do not merely make an infusion of the cacao-bean, but eat it bodily in the form of a soup. It is highly nutritious, one of the most nutritious foods in common use. When traveling on foot in mountainous and other regions, where there was a risk of spending the night *al fresco* and supperless, I have usually carried a cake of chocolate in my knapsack, as the most portable and unchangeable form of concentrated nutriment, and have found it most valuable. On one occasion I went astray on the Kjolenfjeld, in Norway, and struggled for about twenty-four hours without food or shelter. I had no chocolate then, and sorely repented my improvidence. Many other pedestrians have tried chocolate in like manner, and all I know have commended its great "staying" properties, simply regarded as food. I therefore conclude that Linnæus was not without strong justification in giving it the name of *theobroma* (food for the gods), but to confirm this practically the pure nut, the whole nut, and nothing but the nut (excepting the milk and sugar added by the consumer), should be used. Some miserable counterfeits are offered —farinaceous paste, flavored with cocoa and sugar. The best sample I have been able to procure is the ship cocoa prepared for the navy. This is nothing but the whole nut unsweetened, ground, and crushed to an impalpable paste. It requires a little boiling, and when milk alone is used, with due proportion of sugar, it is a *theobroma*. Condensed milk diluted and without further sweetening may be used.

In my last I promised the results of my investigations concerning the source of the sulphate of potash that I found replacing the natural tartrate in so many samples of sherry.

At first I hunted up all the information I could obtain from books

concerning the manufacture of sherry, and learned that the grapes are usually sprinkled with a little powdered sulphur as they are placed in the vats prior to stamping. The quantity thus added, however, is quite insufficient to account for the sulphur compounds in the samples of wine I examined. Another source is described in the books—that from the sulphuring the casks. This process consists simply of burning sulphur inside a partially-filled or empty cask, until the exhaustion of free oxygen and its replacement by sulphurous acid renders further combustion impossible. The cask is then filled with the wine. This would add a little of sulphurous acid, but still not sufficient.

Then comes the "plastering," or intentional addition of gypsum (plaster of Paris). This, if largely carried out, is sufficient to explain the complete conversion of the natural tartrates into sulphates of potash, but such plastering is admitted to be an adulteration or sophistication, and the best makers deny their use of it. I obtained samples of sherry from a reliable source, which I have no doubt the shipper honestly believed to have been subjected to no such deliberate plastering; still, from these came down an extravagantly excessive precipitate on the addition of chloride-of-barium solution.

At last I learned that "Spanish earth" was used in the fining. Why Spanish earth in preference to isinglass or white of egg, which are quite unobjectionable and very efficient? To this question I could get no satisfactory answer directly, but learned vaguely that the fining produced by the white of egg, though complete at the time, was not permanent, while that effected by Spanish earth, containing much sulphate of lime, is permanent. The brilliancy thus obtained is not lost by age or variations of temperature, and the dry sherries thus cooked are preferred by English wine-drinkers.

Here, then, is a solution of the mystery. The sulphate of potash which is thus made to replace bitartrate is so readily soluble that neither changes of temperature nor increase of alcohol, due to further fermentation, will throw it down; and thus the wine-merchant, without any guilty intent, and ignorant of what he is really doing, sophisticates the wine, alters its essential composition, and adds an impurity in doing what he supposes to be a mere clarification or removal of impurities.

I have heard of genuine sherries being returned as bad to the shipper because they were genuine, and had been fined without sophistication. Are we to blame the wine-merchant for this? I think not.

My own experience of genuine wines in wine-growing countries teaches me that such wines are rarely brilliant; and the variations of solubility of the natural salt of the grape, which I have already explained, shows why this is the case. If the drinkers of sherry and other white and golden wines would cease to demand the conventional brilliancy, they would soon be supplied with the genuine article, which really costs the wine-merchant less than the cooked product they now

insist upon having. This foolish demand of his customers merely gives him a large amount of unnecessary trouble.

So far, the wine-merchant; but how about the consumer? Simply that the substitution of a mineral acid—the sulphuric for a vegetable acid (the tartaric)—supplies him with a precipitant of lithic acid in his own body; that is, provides him with the source of gout, rheumatism, gravel, stone, etc., with which *English* wine-drinkers are proverbially tortured.

I am the more urgent in propounding this view of the subject because I see plainly that not only the patients, but too commonly their medical advisers, do not understand it. When I was in the midst of these experiments I called upon a clerical neighbor, and found him in his study with his foot on a pillow, and groaning with gout. A decanter of pale, choice, very dry sherry was on the table. He poured out a glass for me and another for himself. I tasted it, and then perpetrated the unheard-of rudeness of denouncing the wine for which my host had paid so high a price. He knew a little chemistry, and I accordingly went home forthwith, brought back some chloride of barium, added it to his choice sherry, and showed him a precipitate which made him shudder. He drank no more dry sherry, and has had no serious relapse of gout.

In this case his medical adviser prohibited port and advised dry sherry.

The following from "The Brewer, Distiller, and Wine Manufacturer," by John Gardner (Churchill's "Technological Handbooks," 1883), supports my view of the position of the wine-maker and wine-merchant: "Dupré and Thudicum have shown by experiment that this practice of plastering, as it is called, also reduces the yield of the liquid, as a considerable part of the wine mechanically combines with the gypsum and is lost." When an adulteration—justly so called—is practiced, the object is to enable the perpetrator to obtain an increased profit on selling the commodity at a given price. In this case an opposite result is obtained. The gypsum, or Spanish earth, is used in considerable quantity, and leaves a bulky residuum, which carries away some of the wine with it, and thus increases the cost to the seller of the salable result.

Having referred so often to dry wines, I should explain the chemistry of this so-called dryness. The fermentation of wine is the result of a vegetable growth, that of the yeast, a microscopic fungus (*Pencillium glaucum*). The must, or juice of the grape, obtains the germ spontaneously—probably from the atmosphere. Two distinct effects are produced by this fermentation or growth of fungus: first, the sugar of the must is converted into alcohol; second, more or less of the albuminous or nitrogenous matter of the must is consumed as food by the fungus. If uninterrupted, this fermentation goes on either until the supply of sufficient sugar is stopped, or until the sup-

ply of sufficient albuminous matter is stopped. The relative proportions of these determine which of the two shall be first exhausted.

If the sugar is exhausted before the nitrogenous food of the fungus, a dry wine is produced; if the nitrogenous food is first consumed, the remaining unfermented sugar produces a sweet wine. If the sugar is greatly in excess, a *vin de liqueur* is the result, such as the Frontignac, Lunel, Rivesaltes, etc., made from the Muscat grape.

The varieties of grape are very numerous. Rusby, in his "Visit to the Vineyards of Spain and France," gives a list of five hundred and seventy varieties, and as far back as 1827 Cavalow enumerated more than fifteen hundred different wines in France alone.

From the above it will be understood that, *cæteris paribus*, the poorer the grape the drier the wine; or that a given variety of grape will yield a drier wine if grown where it ripens imperfectly, than if grown in a warmer climate. But the quantity of wine obtainable from a given acreage in the cooler climate is less than where the sun is more effective, and thus the *naturally* dry wines cost more to produce than the *naturally* sweet wines.

This has promoted a special cookery or artificial drying, the mysteries of which will be discussed in my next.

SICK-RATES AND DEATH-RATES.

By CL. T. CAMPBELL, M. D.

THE operations of benefit societies ought to provide a fruitful field for investigation by the student of vital statistics. These organizations, embracing a very large membership, deal practically with the accidents of sickness and of death, and can be made to supply valuable data. In Great Britain this has been done, and can be done, with comparative ease. The laws of that country take direct cognizance of benefit societies, and require from them statistical reports of their work, which are tabulated and published by authority. The latest available report of the British Registrar of friendly societies mentions no fewer than 15,379 branches of different organizations of this kind; of which number 12,300, embracing a membership of 4,672,175, had sent the required returns. The experience of so large a number of persons should certainly be of value. And we find that it has been utilized to a considerable extent, for from these returns tables of the expectation of sickness and death have been prepared by a number of English statisticians, including Ratcliffe, Finlaison, and others.

On this continent information concerning the operations of these societies can be obtained only from such reports as they publish themselves. They are not under Government supervision; and their sta-

tistics are not available for purposes of comparison without considerable labor on the part of the inquirer.

As a contribution to this subject, I propose giving the experience of the oldest, and, I believe, the largest, benefit society in North America, that of the Odd-Fellows, which has been in operation sixty-four years, and has a membership of about half a million. Though the society has branches in South America, Australia, Germany, and other places, yet the statistics I shall give will be confined to the membership in the United States and Canada—two countries whose circumstances of race, climate, and social customs are similar.

The membership of the Society of Odd-Fellows is confined to healthy white males, of the age of twenty-one and upward. When I say "healthy," I mean approximately so. In some localities a medical certificate of good health is required from every candidate for membership; and in all cases *prima facie* evidence of sound physical condition is a necessary prerequisite for admission. While, therefore, the society may not consist of lives as carefully selected as the policy-holders of an insurance company, yet they constitute a fair average of the healthy male adults of the Caucasian race. And any possible inferiority to life-insurance subjects in the matter of physical health will be more than balanced by the advantages resulting from the comparatively high standard of morals necessary to membership in a benevolent and moral organization.

The death-rate of this society for the last nine years has been as follows:

YEAR.	Members.	Deaths.	Average.	YEAR.	Members.	Deaths.	Average.
1873.....	414,815	4,013	·0096	1878.....	442,291	4,381	·0099
1874.....	438,701	3,889	·0088	1879.....	440,783	4,530	·0102
1875.....	454,689	4,543	·0099	1880.....	456,942	4,504	·0098
1876.....	456,125	4,317	·0094	1881.....	475,948	5,055	·0106
1877.....	448,019	4,284	·0095				

The average rate for the period embraced in this table appears from these figures to be less than one in 100 (.0097). But the returns come from a very large section of country, with varying conditions, geographical and social, which may materially affect the mortality in special localities. It will be advisable, therefore, to individualize more closely. For convenience, we will classify the several States and Provinces into five groups. We will let the Eastern group embrace Connecticut, Delaware, Massachusetts, Maine, Maritime Provinces of Canada, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont; the Northern—Dakota, Manitoba, Michigan, Minnesota, Montana, Ontario, Quebec, Wisconsin, and Wyoming; the Central—Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Missouri, Nebraska, Ohio, and West Virginia; the Southern—Alabama, Arkansas, Florida, Georgia, Louisiana, Maryland, Mississippi,

New Mexico, North Carolina, South Carolina, Tennessee, Texas, and Virginia; the Western—Arizona, British Columbia, California, Nevada, Oregon, and Washington. This is a somewhat arbitrary division, but it will serve the purpose.

Taking the statistics of 1881, we find the membership, deaths, and rate per 100 in these several groups to have been as follows:

LOCALITY.	Members.	Deaths.	Rate.
Eastern	196,558	2,290	1·11
Northern	50,350	400	·70
Central	165,473	1,552	·95
Southern	34,781	495	1·42
Western	28,523	309	1·08
Total	475,685	5,046	1·06

The apparent conclusion from this table would be that, while in the Eastern, Central, and Western sections the rate did not range very far from the general average, in the Northern it was very much below, and in the Southern very much above. Is this variation characteristic of the localities, or is it due to some special feature of the membership whose experience is tabulated? We find that in the Northern group of States and Provinces the rate is about thirty per cent below the average. But in this section the society is comparatively young; many of its branches have only been in existence a few years; and the membership is composed largely of men in the prime of life, or of those who have but recently passed some test of physical soundness. This might account for the lower rate of mortality. In the Southern section, while there are quite a few old branches, yet in many parts they are as young as in the North—the society having, like all others, suffered by the civil war, and having begun anew during the last fifteen years. We might reasonably expect, therefore, that the rate in the South, though above the average reported, is yet below the actual rate of the locality.

In order to obtain the true death-rate of the average adult male population, it is necessary to confine our investigations, if possible, to those branches which have been in existence for at least the life of one generation; and which will, therefore, contain their just proportion of aged persons. For the year 1881 the statistics were collected of 425 branches in different States, which had been in existence for not less than thirty-five years. In these, with a membership of 51,452, there were 655 deaths, or 1·27 per 100.

It is not possible from the returns to give anything like a correct average for each State or province, or even for each of the groups previously defined. In some States the membership of the older lodges is too small to give results that could form the basis of a correct estimate; but, by grouping some of the States in a geographical classification, we may calculate the average of certain sections. Thus

the Southern States of Alabama, Arkansas, Georgia, Louisiana, South Carolina, and Tennessee have an average of 2·9 per 100; the Eastern States of Maine, Massachusetts, New Jersey, Rhode Island, and Vermont have an average of 1·1; the Central States of Illinois, Indiana, Michigan, Ohio, and Wisconsin, also 1·1; in the Pacific States the society is not thirty-five years old, so that no statistics are obtainable from that quarter; while from other sections the returns were not in a shape to supply the requisite data. But enough was obtainable to show that on the most favorable estimate in tropical States the death-rate is twice as high as in the temperate zone.

Making due allowance for the failure of any of the subordinate officials to send complete returns of their deaths, it is a fair conclusion from such statistics as are available that the average death-rate of the better class of the adult male population of this continent is for the temperate regions 1·5 in every 100; and for the tropical regions three in every 100.

But it is in the matter of sickness that the vital statistics of the United States and Canada have hitherto been most deficient; and in this connection the operations of a large society making weekly payments to its sick members, and thus keeping some record of the amount of sickness experienced by them, can be made useful.

The returns available here, it must be noted, do not give the full sickness experience. Reports are made only of the number of weeks for which sick-benefits are paid. Usually a person must be a member a certain length of time, from one to six months, before he is entitled to benefits; in some localities no benefits are paid for the first week of sickness; members who are in arrears to the society receive no benefits. So that the actual average of sickness will be somewhat in advance of the figures given.

Taking the entire society in the United States and Canada, we find the following returns for the last seven years:

YEAR.	Members.	Weeks' benefits paid.	Average.	YEAR.	Members.	Weeks' benefits paid.	Average.
1875.....	454,689	211,148	·4667	1879.....	440,783	246,768	·5959
1876.....	456,125	230,398	·5160	1880.....	456,942	251,448	·5502
1877.....	448,019	221,319	·4939	1881.....	475,948	285,081	·5989
1878.....	442,291	237,709	·5368				

Submitting these returns to the same system of grouping that we adopted with the mortality returns, we have the following result:

LOCALITY.	Members.	Weeks' sickness.	Per member.
Eastern.....	196,558	148,311	·754
Northern.....	50,350	13,446	·266
Central.....	165,473	72,667	·439
Southern.....	34,781	32,417	·946
Western.....	28,523	18,967	·665

A noticeable feature of this table is that the death-rate and sick-rate bear a close relationship in the several localities. To make it more apparent, we place them in parallel columns :

LOCALITY.	Deaths in 100.	Weeks' sickness per member.
Northern	·70	·266
Central	·90	·439
Western	1·08	·665
Eastern	1·11	·754
Southern	1·42	·946

In order to obtain, however, the average for the general population, we turn to the older branches, with the following results : For 1881, there were 655 branches over thirty-five years old, reporting 83,121 members, with 79,902 weeks' sickness—being an average of ·961 of a week. We find that the Eastern section, with 60,783 members, reports 63,295 weeks' sickness, or an average of 1·041 ; and the Central reports 15,839 members and 13,211 weeks—an average of ·834. The returns from the Northern and Southern States are insufficient for a fair comparison ; but the fact that one State alone, Maryland, with a membership of 10,785, reports 21,259 weeks' sickness, is an evident indication that there is the same proportionate advance in the rate in every locality.

Judging from the experience of this society, it is a reasonable conclusion that the average sickness of the better class of the adult male population of the United States and Canada is one week and a half each year.

But a more important calculation, which can be made from the statistics of benefit societies, is the expectation of sickness for each year of a person's life. This has been computed in England by several actuaries. While they have not agreed entirely in details, for the simple reason that they have taken the experience of different classes of people, yet they have agreed on the general principle that there is a regular increase in the average of yearly sickness with each year of a person's life. The statistics of the Society of Odd-Fellows in America have also been tabulated at different periods during the last thirty years. The first calculations were made in 1854, and were based on the experience of 66,000 persons. The plan adopted for securing the necessary data was to require each subordinate branch to send to the central authorities a return of the number of members at each year of age, of the number sick at each year of age, and of the number of weeks' sickness for each age. This process has been repeated at different periods and in different States. In some States it is done every year.

From the data thus obtained has been compiled a table of the expectation of sickness, which has been published by the authorities of

the society as a basis for the use of the membership in the arrangement of their beneficial system. As this table has never, so far as I know, been published outside the society's own journals, I submit it here, with the expectation of life, according to the American tables:

AGE.	Expectation of life—years and decimals.	Expectation of sickness for that year—weeks and decimals.	AGE.	Expectation of life—years and decimals.	Expectation of sickness for that year—weeks and decimals.
21.....	41·5	·450	41.....	27·4	·763
22.....	40·8	·455	42.....	26·7	·803
23.....	40·2	·460	43.....	26·	·843
24.....	39·5	·465	44.....	25·3	·885
25.....	38·8	·470	45.....	24·5	·930
26.....	38·1	·476	46.....	23·8	·980
27.....	37·4	·483	47.....	23·1	1·035
28.....	36·6	·491	48.....	22·4	1·095
29.....	36·	·499	49.....	21·6	1·166
30.....	35·3	·509	50.....	20·9	1·230
31.....	34·6	·520	51.....	20·2	1·308
32.....	33·9	·532	52.....	19·5	1·396
33.....	33·2	·545	53.....	18·8	1·494
34.....	32·5	·560	54.....	18·1	1·604
35.....	31·8	·578	55.....	17·4	1·730
36.....	31·1	·599	56.....	16·7	1·875
37.....	30·3	·624	57.....	16·	2·040
38.....	29·6	·653	58.....	15·4	2·230
39.....	28·9	·686	59.....	14·7	2·450
40.....	28·2	·723	60.....	14·1	2·700

PROPERTIES AND CONSTITUTION OF SEA-WATER.

By M. ANTOINE DE SAPORTA.

IT has been said that, without the sea, civilization could not have been developed, and the world would have continued barbarous. That element, from the primitive times of mankind, has brought together the peoples of the most distant countries, and inspired the ancients with the idea of the Infinite. Homer believed in a river Oceanus; the Hindoo mythologians in a liquid expanse, boundless as space. The fishermen who set their rude nets in the creeks of the Cyclades were, perhaps, the first naturalists, and the Phœnician sailors may have been the first marine engineers. In our own time, all the sciences find in the ocean either a limitless field of exploration, or an enemy to be conquered. Zoölogists, closeted in their laboratories, endeavor to determine the beings which the dredge has brought up from frightful depths, while hydrographers and constructors study the currents, raise jetties, and excavate ports. The public visit the aquariums, admire the dikes and excavations, and applaud what they see, but do not see all. Our purpose is to explain the researches of the

modest investigators who have occupied themselves with the chemical constitution and physical properties of sea-water.

Sea-water, it is well known, when it is not muddy, is one of the clearest of all natural waters. When we walk along the shore at low tide, it is often difficult, unless we are careful, to keep from stepping into the occasional pools on the rocks, the water in the little hollows being so transparent as to be invisible. The question of the color of this water deserves serious examination, and labors on the subject are not wanting. The most notable ones are those of Father Secchi, of Professor Tyndall, and the more recent researches of M. W. Spring and M. Soret.

Father Secchi made his experiments in 1865, on board a Pontifical corvette. A number of disks, formed by stretching variously-colored cloths over iron hoops, the largest twelve feet in diameter, were let down at a time when the conditions of the weather were most favorable for transparency. The largest disk, which was painted white, became invisible at the depth of about forty-two metres, while the smaller disks and a delf plate, distorted by refraction, went out of sight at smaller depths. The disappearance seemed to depend upon the confusion of the image, which was broken up in every direction. The largest disk, the considerable surface of which offered more resistance to the distortion, finally ceased to be perceived, because its color, turning in succession to light green, blue, and dark blue, became at last as dark as the surrounding medium. Disks, painted yellow or red, were lost to sight still more quickly, or under not more than twenty metres of water. Repetitions of similar experiments gave co-ordinate results; and it may be stated, as a general rule of average, that the practical limit of submarine vision, under favorable circumstances, is at twenty-five metres under the surface.

It was found, by spectroscopic examinations of the light reflected from the differently colored disks, that the yellow was enfeebled and extinguished first, and next the red, under the increasing thickness of the overlying water. By the gradual disappearance of these two colors, a white object is made to pass through green to blue—the tint which all such objects finally assume when sunk under salt-water. Each of the three simple colors—yellow, red, and blue, or violet—has its distinct part among the solar rays. Yellow is luminous, red is calorific, and violet-blue provokes chemical reactions. Water, in a very thick mass, is neither transparent nor diathermanous; but, being penetrable to the blue, indigo, and violet rays, it is diactinic. These radiations, too, will, of course, gradually lose their energy, and become extinguished at last in a very deep stratum of liquid; but the limit is extremely remote.

According to the theory propounded by Professor Tyndall, the sea-waves present three principal hues—blue, green, and yellow. The indigo-blue waters are the purest, while the yellow ones contain muddy

matters in suspension, and the green ones are slightly charged with such substances. The solid particles held in the water constitute a multitude of infinitely little mirrors, from the outside of which is reflected the light that penetrates the mass of the liquid. The rays which are sent out, after having traversed only a thin stratum of water, preserve their yellow parts. If the reflections are attenuated, the water appears green; and if, on account of the absence of solid matter, they do not exist at all, the sea is of a deep blue. In an indigo sea, the crests of the waves will appear green on account of their lack of thickness. The same rules are applicable to fresh water; for the salt is almost without effect on the color of sea-water—not quite without effect, for, according to M. Spring, the clayey particles which make the waves yellow are precipitated with a rapidity proportioned to the salinity of the sea. These general laws are liable to be disturbed by numerous accidental circumstances or local causes. The presence of sea-weed, or of microscopic animalcules, may have great influence on the color of the water. In tolerably shallow basins, the color of the bottom has its effect.

Several seas or gulfs have been given names alluding to their colors. Some of these terms can be explained without difficulty, but others are not so easy to comprehend. The White Sea is so called on account of its ice, the Black Sea from its storms, and the Yellow Sea from the muddy waters poured into it by the Chinese rivers. The waves of the Vermilion Sea, near California, are colored by the Rio Colorado, which itself has a characteristic name. The water that washes the European coasts has no perceptible odor; or, if in single cases it may be odorous, the smell is due to mud, or to decomposing organic matters contained it it. Drinking-water, which is stored for some time may also acquire a smell which it had not at first, through the decay of the impurities in it. The cork of bottles containing salt-water is sometimes eaten by sulphuretted hydrogen formed in the water.

Sea-water owes its characteristic taste to the chloride of sodium held in solution, and to the bitter salts of magnesia which it contains. Sometimes organic remains or weak proportions of fatty matters become mixed with the superficial strata, so as to make them more nauseous than the same water drawn from greater depths. The pleasant taste of the water inclosed in oyster-shells is due to the savory animal juices that are dissolved in it. Mussels, which live and are fished near the shore, sometimes absorb impurities from the drift-matter around them, from which they develop the poisonous alkaloids called *ptomaïnes;* hence they are unhealthy at some seasons.

By a scientific prejudice that ruled for a considerable time, the bitter taste of sea-water was believed to be caused by traces of bitumen. The chemists who made analyses consoled themselves for not finding a sign of that substance, the existence of which they suspected, by sup-

posing the proportion was too slight to be appreciable. Count Marsigli, who in the reign of Louis XIV tried to make sea-water artificially, took great pains to mix bitumen with the salts he put in solution, in order to make the reproduction perfect. The partisans of the theory cited the Dead Sea, which was near asphalt-beds, and the waters of which were insupportably bitter. But Macquer, assisted by Lavoisier, a hundred years ago, carefully distilled specimens of this water, and found in it no more bitumen than had been found in Mediterranean water—which was none at all. He attributed the bitter taste of this water to the presence of salts of magnesia.

It is not to-day that investigators have sought to make sea-water potable by removing its nauseous taste. The problem was solved long ago, and, as often happens, the usefulness of the invention once so greatly desired has been much depreciated. When fresh water for the provisioning of vessels was stored in wooden casks, it was liable to spoil in a short time. Now it is carried in large iron tanks, in which, instead of spoiling, it is improved by acquiring a ferruginous quality. The ancients did not venture far from the shores, and were contented with a simple coasting-trade; nevertheless, this question interested them, and Pliny describes two means of freshening the water of the Mediterranean, one of which is absurd and the other impracticable: One was to plunge into the sea hollow balls of wax, which, the author affirms, would be filled with pure water; and the other was to expose fleecy sheep-skins on the deck of the vessel, to collect the morning dews.

Whoever examines the series of memoirs published during the seventeenth and eighteenth centuries, on the subject of freshening sea-water by distillation, must be struck by the divergence of opinions and the want of concordance in the results, some declaring that distilled water is pure, healthy, and tasteless, others that it is unhealthy and almost as detestable as before the operation. The differences between them are easily explained. Marine salt is not the only substance dissolved in the water, but is accompanied by several other bodies, the principal of which is chloride of magnesium. This salt when dry resists the action of the most violent heat without changing; but in boiling water undergoes a double decomposition, in which the chlorine leaves the magnesium to unite with the hydrogen of the water, while the oxygen thereof unites with the magnesium. There is thereby produced magnesia, which remains in the vessel, and hydrochloric acid, which is distilled over. Now, distilled water is made impotable and unhealthy by any traces of that acid. The difficulty may be obviated by previously removing such salts as can be made to settle, or by adding fresh sea-water. Water boils at a temperature several degrees higher than usual when it is charged with salts. If it is sufficiently diluted it will not disengage hydrochloric acid. Or the acid may be absorbed by substances added to the water for that purpose, and which

will not give it up again. Such substances are lime, chalk, potash, soda, and calcined bones, all common and cheap.

The problem of freshening sea-water was formerly regarded as so important that other means of solving it besides that of evaporation were advanced. Even the great Leibnitz lent his name to a proposition which was judged singular, if nothing worse, by his contemporaries. It was to freshen water by forcing it through a filter filled with litharge; but he never tried the experiment. It was believed, on the authority of Pliny, that if an empty bottle, hermetically sealed, were sent down deep into the ocean, it would come back full of pure water. But it was proved that the bottles would either be broken or come back empty. Other naturalists tried filters of earth or sand. But, when Réaumur and the Abbé Nollet constructed a gigantic filter of glass tubes filled with sand, a thousand toises long, they found that the water came out of it as salt as it went in. Lister, in 1684, placed sea-weeds with their stems in water, after the fashion of a bunch of flowers, in an alembic which he did not heat, believing that the fresh water would ooze out in drops from the upper part of the plants; but he had to acknowledge that no great result came from his curious process. Samuel Reyer made a discovery of some practical value—that melted sea-ice furnished a potable water. Notwithstanding numerous distilling apparatus were devised by various inventors, ships continued to be furnished until very recently with water stored in casks. The inventions had little practical value, and the management of alembics when the sea was rough was a matter of considerable difficulty.

The sea is in reality an immense and inexhaustible mineral spring. Probably, if it only contained pure water, a fountain as rich in mineral matters as the ocean actually is would attract crowds of drinkers and would be recommended for internal use in all imaginable diseases. But sea-water is abundant and common, and has never been much used internally. On the other hand, the therapeutic employment of sea-baths might be made the occasion of long dissertations.

It is generally known that a strong dose of sea-water acts as an emetic; in weaker proportions it is purgative and diuretic. Dioscorides advised diluting it with honey, which might, perhaps, produce an efficacious medicine, but certainly not a savory one. At the beginning of this century it was diluted with wine, but such a mixture could hardly be better than the other one. It was prescribed in Spain against the yellow fever, and in England against worms: in the former case, as an emetic; in the second case, milk was added to it so that the child could drink it without aversion. Sea-baths have been tried as remedies for hydrophobia and insanity, but, it is needless to say, without effect.

Marine water contains a little iodine; it is therefore a resolvent, and adapted to external application for tumors and ulcers, although more

energetic and sure remedies are generally employed. Even before iodine was discovered, more than a hundred years ago, Russel had remarked the efficacy of calcined sponges and corals, and of the ashes of sea-weed, substances richer in iodine than sea-water itself.

A general study of the physical properties of sea-water would not be complete if it was limited to that at the surface. It is necessary to obtain specimens drawn from different depths, especially as the density and temperature vary with the depth. Various apparatus have been contrived for bringing to the surface a quantity of water drawn from any desired level. A long-known means, and at the same time a simple and practicable one, is to let down by a rope an empty bottle corked. The increasing pressure upon the bottle becomes strong enough at certain depths to push the cork in and fill the bottle. The rope is then drawn up, and the liquid inside the bottle coming in contact with less dense waters, pushes the cork back into the neck of the bottle and closes it. Thus the water from the deep keeps itself free from mixture with that of the superficial levels. Other more perfect apparatus have been invented, all dependent upon the automatic closing of the vessels.

Salt water is denser than fresh, because of the gravity of the dissolved salts. But wherever large rivers enter the sea, as in the Black Sea and the Baltic, and in cold climates where evaporation is slow, the superficial water is light and of inferior salinity. The water of the Norwegian fiords is brackish, and that of the Gulf of Bothnia, at the upper end of the Baltic, is, in an extremity, potable. The glaciers of Greenland and Spitzbergen pour out in the summer torrents of fresh water which tend to freshen the spaces around their mouths. There is likewise a deficiency of salt in the waters of the White Sea, the Kara Sea, and the Siberian Ocean. Inversely, the Mediterranean, which does not receive, in proportion to its extent, so many nor so large rivers, and is exposed to the ardors of a burning sun, would become indefinitely concentrated by evaporation, were it not that an under-current of less dense water was sent into it by the Atlantic Ocean through the Strait of Gibraltar. Copious rains may play some part in the matter, and that is another reason why Mediterranean waters should preserve their density. Evaporation is very great in the tropics, but the liquid concentrated by it is also expanded by the heat, so that the two effects partly balance one another.

In all the old books on the physics of the globe, and even in some recent ones, no difference was made as to the law of maximum density between salt water and fresh. The latter begins to expand by heat at 4° C. (39° Fahr.), but, between the freezing-point and that temperature, it contracts when it is warmed, so that at 39° Fahr. it is denser than at any other temperature. In temperate countries, the water of the bottom of deep lakes remains at nearly 39° Fahr. by means of its weight, which prevents it from rising to the surface and

mixing with either the colder or the warmer parts, and also because water conducts heat very badly.

The phenomena are different in the case of sea-water, and also complicated in other ways. The point of maximum density descends as the weight of the salt-water and its richness in dissolved matter increase. The Swedish chemist and hydrographer, Ekman, after long series of experiments relative to this question, has found that this critical temperature may fall to —4° C. (25° Fahr.) in Atlantic water. The properties of a brackish fluid, such as would be drawn from a fiord, would naturally be intermediate between those of a pure and those of a very salt water. Hence the depths of the ocean can not be at 39° Fahr., as some authors still maintain. A slight excess of salt in solution will weight a stratum of water of mean temperature, whereby a cold zone may be superposed upon another zone which is warmer but more saline. The interior of the ocean, as well as its surface, is plowed by numerous currents, some warm, some cold, which meet, mix, and separate again, so that it is very hard to find out by reasoning what experiment alone can teach. A similar variety is shown in the density of water brought up by soundings. The complication is magnified when we reflect that water is not absolutely incompressible, that each thickness of ten metres exercises a vertical pressure nearly equal to an atmosphere, the action of which added to that of the superior parts weighs upon the inferior liquid, so that at about 4,000 metres the pressure is 400 atmospheres. Water must be extremely dense when it it compressed with so much force, and the influence of salinity and temperature must become very small in these unfathomable abysses. The question of submarine temperatures has given rise to many controversies. Some, with Perron, suppose that the great depths are always cold, like the tops of the highest mountains. On the other extreme, the author of "Epochs of Nature" attributed to the oceanic depths a high temperature on account of their nearness to the central fire. Denis de Montfort and Humboldt are of the opinion that below the superficial parts there prevails a constant temperature, peculiar to each station, and corresponding with the mean annual temperature of the place. This view is correct for regions where the depth is not very great, and in certain bodies of water.

The sea, on account of its great specific heat and its feeble conducting power, plays the part of a moderator of temperature something like that of the fly-wheel of an engine as a moderator of force. In winter it is warmer, in summer it is cooler, than the ambient air, and the difference is emphasized the farther we get away from the shore.

In "The Clouds" of Aristophanes, Strepsiades refuses to pay his creditors who hold that the level of the sea is fixed, believing that, as it receives all the water, it must continue to rise indefinitely. The phenomena of evaporation were not very well understood at that time. Even in the seventeenth century, Father Fournier talked of subterra-

nean fissures or crevasses in which the waters of the Baltic and the Mediterranean, incessantly swelled by the rivers and by the currents of the Sund and of the Strait of Gibraltar, constantly lost themselves. During the last three years, the question of the evaporation of sea-water has been much discussed between the partisans of the Saharian sea and their adversaries. The great point was to ascertain whether the proposed sea would not in the end become an enormous marsh. The sub-commission of the French Academy of Sciences was of the opinion that, other things being equal, salt water would evaporate less rapidly than fresh. Experiments by M. Dieulefait, on the other hand, indicated that a nearly equal loss would occur in the case of salt water and of fresh.

Fresh water freezes at 32° Fahr., but a liquid charged with salt congeals at lower temperatures; the rule is about the same as for the maximum of density, except that water slightly salt undergoes its contraction before being converted into ice, while normal sea-water acquires its minimum volume only in a state of surfusion, or when maintained artificially in a fluid state in capillary tubes. In this condition, a number of substances, water among them, are susceptible of being cooled considerably below their point of congelation and still remaining liquid. In the Baltic and White Seas, the waters of which for some depth are but weakly charged with salt, ice forms on the surface when the surrounding temperature has become low enough, while immediately below are strata more dense and relatively warmer. But suppose that below a certain depth of a brackish and warm liquid there is a cold salt current; the latter would produce such a refrigeration in the mixed intermediate strata that a mass of ice would be formed in the interior of the sea at the expense of the less saline zone. The block when formed would rise to the surface by virtue of its specific levity. This is what happens at the mouths of the great Siberian rivers. The Lena, in particular, pours out an enormous mass of warm water which overwhelms the salt waves from the polar regions. Even in the most favorable seasons, the navigator sails in the midst of floating ice-cakes that constitute a constant source of danger, while the thermometer dipped in the sea will indicate a temperature above the freezing-point. The depth of the warm stratum varies with the year, the place, and the prevailing winds; and hence we account for some explorers declaring impracticable tracks which others have easily sailed over. The northeast passage along the Siberian coast can never become a regular commercial route, unless, by repeated soundings accompanied by attentive studies, we can finally discover regular and periodical laws for the phenomena under consideration.

The Swedish physicist, Edlund, having inquired of the Scandinavian fishermen, was assured that they had sometimes, though rarely, seen the sea near the fiords of their country "vomit fragments of ice." The following is a textual reproduction of the story of one of the sail-

ors concerning this curious and still little-known fact: "Not every year, but times enough, out on the open sea, I have seen ice come rapidly up to the surface. If the weather is calm, we can perceive, as far out as we can see, small cakes in the shape of a plate, coming from the bottom, rise to the surface. The edge is in the air, but, when the upper part of the plate gets above the level of the water, the plate turns over and lies flat upon the liquid. It is a dangerous business, for a boat may thus in a few minutes be surrounded by immense masses of new ice." *

Aside from this anomaly, the formation of isolated blocks of ice in the open sea is very rare. Water of ordinary salinity becomes denser as it cools, for it freezes at about 28° Fahr., and, as we have explained, attains its maximum density at about 35° only if we keep it artificially in the liquid condition. Water that has lost its caloric in contact with the atmosphere soon sinks; sometimes, as Scoresby attests, ice which is formed at medium depth rises to the surface, while sounding thermometers indicate temperatures near or even below the point of congelation at the bottom. Otto Petterssen is of the opinion that, if water submitted to a cold of a few degrees below its freezing-point does not solidify, it is because immobility favors surfusion, or rather, what is very possible, because we do not know all the laws of nature.

Mr. Petterssen has succeeded by a series of experiments in explaining a variety of phenomena which manifest themselves in the boreal seas, and which Arctic explorers have long been acquainted with, without understanding the reason of them. Sea-water, after its passage to the solid state, has not the same chemical composition as before; but besides this change, which we shall speak of again, it has another interesting peculiarity. If the temperature is very low, the ice of the ocean, like nearly all known bodies, contracts by cold; but at a few degrees below the freezing-point, and before melting, it diminishes in volume when heated, and dilates on cooling. Between 14° Fahr. and − 4°, according to the age and source of the block, there is produced a minimum of density, the mass acquiring its maximum volume—that is, the behavior of the solid is the inverse of that of river-water.

While it contracts by heating at about 18° or 23° Fahr., the ice of salt-water loses some of the properties which it possesses at lower temperature, and which are common to it with ordinary ice. It has no longer the vitreous aspect, the fragility, and the homogeneity of solid ice, but becomes softer, more plastic, and less transparent; its fracture is less distinct, and cracks and holes multiply in it. And, when brackish water congeals, it loses its disagreeable taste, but its bad looks and want of limpidity deprive it of commercial value.

Sea-water is a very complex saline solution; chemical analysis discovers in it halogen radicals, simple, as chlorine and bromine, or com-

* We owe these details to the kindness of M. Otto Petterssen, who has furnished us with many interesting facts, the fruits of his personal observations.

pound, as sulphuric acid and the four basic principles, soda, magnesia, lime, and potash. Chlorine is by far the most abundant principle, and should be credited with more than half the weight of the saline matter. Open any book on chemistry or the physics of the globe, and you will find that sea-water contains, by the litre, so much chloride of sodium, so much sulphate of magnesia, so much chloride of magnesium, etc. These affirmations are wholly hypothetical, for our acquaintance with chemistry is not sufficient to permit such conclusions. Analysis shows that there are in a litre of sea-water so much chlorine, so much sulphuric acid, and so much magnesia, but does not reveal to us how the radicals are united, for the combinations we get in analysis are not probably precisely the ones that existed in the water. We might say that the numerous simple bodies entering into the composition of sea-water are all the time contracting new and incessantly variable alliances, according to the temperature or the concentration of the liquid. It is by intelligently utilizing these laws that they succeed at the salt-works in forcing the mother-waters to deposit at one time cooking-salt, at another time some other combination useful in industry, or which it is desirable to get rid of.

In evaporating to dryness a known quantity of sea-water, under certain precautions, we obtain a residue which, well dried and weighed, furnishes the weight of the total quantity of salts originally dissolved. It is then easy, by a simple calculation, to estimate the proportion of solid substances contained in a litre. Salt-water is denser than fresh water of the same volume and temperature, and this excess of density is evidently proportional to its richness in saline matters. This can be obtained by multiplying the excess of density by 1·32. We may thus replace the chemical operation by a determination of density, an easier experiment, and one that can be made on board ships.

The different oceanic regions are not equally rich in salts. What we have said respecting variations of specific weight shows this very clearly. But, if we always draw the water from a sufficient depth, the variations become much less, as Forchhammer has proved. The figures in his tables oscillate between thirty-four and thirty-five grammes per litre. The relative proportion of the different elements is still more invariable, and we can establish a few slight differences only by taking the means of a large number of estimations. This fixity of relation might have been foreseen, because evaporation concentrates, without taking away an atom of salt, while fresh waters dilute without furnishing any. It follows, then, that the composition of a specimen of sea-water can be estimated with a fair degree of accuracy by ascertaining the proportion of one of its constituents, the chlorine, for instance, and that element is much used as a standard. The amount of chlorine in a litre of liquid collected along the shore diminishes obviously when the ship is approaching ice, or if it is cruising near the mouth of a great river.

When concentrated by any means, sea-water deposits, first, carbonate of lime, next gypsum, or sulphate of lime, and then salt; and, lastly, the salts of magnesia and the bromides. The phenomena are not quite so simple in practice, and the deposits of salt-marshes are rarely composed of a single substance; but we have only intended to indicate the general course of the operation. The salt of commerce is rich in magnesia, or chloride of magnesium, in proportion to the strength of the concentration. Some have even sought to ascribe the enormous deposits of gypsum found in certain regions to ancient seas which, in drying up, deposited that substance among the first.

Potash and the bromides, substances that are relatively little abundant, accumulate in the mother-waters till they become so condensed as to make the industrial working-out of them remunerative. Bromine is less abundant in the Mediterranean than in the waters of the Dead Sea, which may some day become a source of production. Eighteen centuries ago the Romans, according to Pliny, brought to Italy at great expense the water of the Asphaltine Lake, the curative properties of which were held in high esteem. The excess of bromine in this water, however, corresponds exactly with its greater total saltness, so that, except for a few qualifications to which we shall refer again, the relative composition of the dry residue of the Dead Sea is the same as of that from the ocean. In other words, any marine water evaporated to the same degree of density as that of the Dead Sea would be as deleterious to living beings.

Marine ice was formerly regarded as formed of solidified pure water retaining by mechanical adhesion traces of the saline liquid. These traces could be expelled by energetic pressure, when acids and bases would be found in the residue of desiccation in invariable proportions as in the sea. The question of chemical composition of the ice of the Arctic Ocean is complicated in other ways, but it gains in interest what it loses in simplicity. When salt-water is cooled artificially, a small part escapes solidification. The uncongealed residue is insupportably bitter to the taste, and analysis shows that nearly all the magnesia is concentrated in it. The solid block, if it is homogeneous and is not full of holes, and if previously drained, may furnish a passable drink. The natural ices of the Northern Sea are frequently moistened with a kind of brine, which sometimes embodies crystals of special character, easy to distinguish from the ice around them. According to Otto Petterssen, the relative proportions of chlorine and magnesia are much stronger in these exudations than in the water at the expense of which the ice is formed. The liquid can not then have been mechanically absorbed. On the other hand, there is a deficiency of sulphates; and the conclusion that sea-water ice retains the sulphates more abundantly is confirmed by analysis. With congelation, a sorting of matters takes place; most of the sulphuric acid passes into the part that solidifies, while magnesia and chlorine prevail in the part

that remains liquid. Under the influence of variations of temperature, all the chlorides in the block will gradually disappear: some go into the sea and are dissolved; while the rest appear on the surface and form hydrated crystals, or a kind of "salt-snow." The sulphates thus prevail exclusively in old ices, which, according to Mr. Petterssen, constitute mixtures of solidified water and a peculiar chemical compound, the criohydrate of sulphate of soda, a body which, containing five parts of soda to ninety-five of water, is decomposed at a little below the ordinary freezing-point.

By these phenomena of selection, ice, under atmospheric vicissitudes, approaches a limit when its composition would be fixed, without reaching it in reality. Usually, the expulsion of chlorides is not complete, and sudden changes of temperature may liquefy it at once. The Swedish observer compares the ice of salt-water with a kind of granite, each constituent of which should take its turn at decomposing under special circumstances. The warm waters farthest from the pole would bear only the stable constituents brought down by the Arctic current, so that, to continue our comparison, the river, which has gradually eaten away the granite block, finally transports the last remains of the rock in the form of sands and clays, which are destined to accumulate in the sedimentary deposits.

Over and above the substances that exist in considerable proportions, many rarer elements are found in the waters of the ocean; minerals, gases, and organic remains, difficult perhaps to recognize, sometimes impossible to estimate, but which nevertheless play an important part. The phenomena of accumulation which we have considered are absolutely insignificant in comparison with the absorbing power of some of the algæ. In them Courtois discovered iodine in 1812, and Malagutti, after laborious researches, detected copper, lead, silver, and iron, metals which he afterward found in sea-water itself. The quantity of iodine contained is so little appreciable that many doctors have denied the therapeutic virtues which others have attributed to this water. Nevertheless, absorbed and condensed by marine plants, it becomes abundant enough to be extracted with profit. It likewise accumulates in animal organisms; and cod-liver oil owes its beneficent properties to it. The silver was absurdly attributed by Proust to the treasures of shipwrecked vessels. But the quantity, though infinitesimal in a measured quantity of water, is in the aggregate immense. Malagutti more rationally refers its origin to the solution of the lead-ores, very abundant all over the globe, with which sulphurets of silver and copper are combined. By the action of salt, the sulphurets are converted into chlorides. As to iron, it would be strange if so universal a substance were not found in the sea; and the same may be said of phosphoric acid.

The researches of M. Dieulefait into the presence of lithium in sea-water have shown that the Dead Sea is an independent body of

water, and not an abandoned lagoon of the Red Sea. By chemical and spectral analysis, it contains neither iodine nor silver, nor lithine, while all those substances are found in the Arabian Gulf, a body whose waters differ from those of the oceans only by their greater density consequent on the strong evaporation to which they are subjected.

The determination of the air dissolved in the ocean is attended with many difficulties. We can only indicate a few prominent principles. This air has not the same composition as the air we breathe, although it differs but little in that respect from the air held in springs and rivers. Oxygen, which forms only a fifth of the atmospheric air, being more soluble in water than nitrogen, constitutes about one third of the air which is expelled from water by boiling. The volume of gas absorbable by water diminishes as the temperature rises. Cold water is richer in air than warm. Moreover, the law of decrease being regular for nitrogen, while it is less simple for oxygen, the relative proportions of the two elements are variable in waters of different temperatures. According to Mr. Tornöe, there is a little more oxygen at the surface than theory calls for, while in the zones where animal life is largely developed there is a slight deficiency. The presence of sunlight, or the cutting of it off by clouds, has no important effect; and the same may be said of the enormous pressures to which deep-sea waters are subjected. But little carbonic acid occurs dissolved in a free state, although that gas is very abundant in combination. Mr. Tornöe, who has given this subject careful attention, thinks the older chemists collected carbonic-acid products of the decomposition of carbonates or bicarbonates at the boiling-point He finds an alkaline reaction in sea-water, which he attributes to a small quantity of free salts of soda. Mr. Hamberg, a Swedish chemist, who has recently studied the waters of the Greenland seas, agrees with Mr. Schloesing that marine water contains neutral carbonates, bicarbonates, and slight traces of free carbonic acid, and that temperature and atmospheric pressure have a complex influence on both the uncombined gas and that which is united to bases.—*Translated for the Popular Science Monthly from the Revue des Deux Mondes.*

WHY BIRDS SING.

By Dr. B. PLACZEK.

I HAVE long been an interested observer of bird-life. The situation of my house and garden, on the terrace-slopes of the Spielberg, affords me favorable opportunities for studying the habits of the feathered tribes. They build their nests in my garden, and lend themselves with great docility to the purposes of the friendly spectator of their movements. At one time the nest of a hedge-sparrow (*Sylvia*

curruca) attracted my attention ; I noticed particularly the increased care that was taken by the parent birds, as feeding-time approached, against unwelcome discovery. It was manifested, first, in a cessation of singing, and then in the combined efforts of the pair to divert strange looks from the nest. The birds, when about to take food to their young, were accustomed to fly down from opposite sides, and while one, after many cross-flights through the overhanging foliage, slipped into the nest, the other would flutter wildly hither and thither in another part of the tree. The three half-fledged young birds, when able to glide through the bushes, but not yet to fly, were dislodged from the nest, and while two of them disappeared with the mother, I caught the third, against the anxious remonstrances of the male, and hung it up in a cage in my veranda. The old male stood faithful to his chick, evidently concentrating his whole attention upon it, hopping around among the trees and collecting insects for it from early in the morning till the coming on of night, unceasingly, and never out of the neighborhood. He was accustomed to sound a grating *zapp, zapp*, in which the young one soon learned to join, in a variety of tones constituting a whole gamut of modulated sounds, from the note of cheerful pleasure to those of anxiety and anger, and was moved to utterance by the most insignificant event in the cage or around it.

I observed that the male bird, which had sung much less than usual while the female was sitting, and had ceased to sing entirely as soon as the young ones were hatched out, resumed his old habit of song as soon as the fledgeling's domicile was changed from the nest to the cage. He would execute a kind of strophe of from seven to nine clear, ringing notes, having sometimes a joyous and sometimes a melancholy expression. What was the meaning of the song which he thus resumed? Was it poured out to dispel the sorrow of the lonely orphaned young one? Did the absence of the female give the male a greater liberty in the matter? Or, was it sung in hopes of bringing the female back, or in rivalry with another male? Pondering over such questions as these led me to reflections and observations on the origin and meaning of the songs of birds.

While we may regard the ordinary vocal utterances of birds as expressions of their moods and wants, signals of intelligence, notes of warning, or calls for help, their song proper must be supposed to describe their more deep-felt emotions and anxieties, and to be related to their common expressions of sound as art is related to the handicrafts that minister to the necessities of life. Like art, the bird-song also, repeatedly exercised, may become an habitual mode of expression.

The majority of ornithologists agree in ascribing an erotic character to the songs of birds ; not only the melting melodies, but also those of their tones that are discordant to the human ear, are regarded as love-notes. Darwin finally, saving some reserves, came to accept

this view. To be able to speak critically of the love-song, one should pay especial regard to the love-life of birds. It would be to throw water into the sea to add to what ornithological writers have advanced concerning the exceeding vital worth and cosmical significance of love. Nevertheless, I venture the opinion that the origin of the song-habit is to be found in other sources as well as in this important factor, among which is the joy of life, manifested in an irresistible determination to announce itself in melody; and that the song is more perfectly brought out in proportion as this feeling is more highly developed in the organization. Birds in freedom begin to sing long before pairing, and continue it, subject to interruptions, long afterward, though all passion has been extinguished; and domesticated birds sing through the whole year without regard to breeding-time, though no female or companion ever be in sight. Such birds, born in captivity, never feel the loss of freedom, and, if they are well taken care of, are always hearty and in good spirits. The bird sings, to a large extent, for his own pleasure; for he frequently lets himself out lustily when he knows he is all alone. In the spring-time of love, when all life is invigorated, and the effort to win a mate by ardent wooing is crowned with the joy of triumph, the song reaches its highest perfection. But the male bird also sings to entertain his mate during the arduous nest-building and hatching, to cheer the young, and, if he be a domesticated bird, to give pleasure to his lord and the providence that takes care of him, and in doing so to please himself. Lastly, the bird sings—by habit, as we call it—because the tendency is innate in the organs of song to exercise themselves.

My male hedge-sparrow, whose truly devoted care of its solitary young one I have described, began, after a ten days' pause, to sing more frequently and intensively, although neither a female nor a male of his species was in the neighborhood, apparently to cheer his ward. His evening farewells, uttered in a clear voice, were peculiarly expressive and touching. When, after eight days more, the chick began of itself to pick food from the dish and to snap at flies, the old bird discontinued its daytime feeding and singing, and came only at night. When the young bird was ready to fly, it came no more.

Female birds, as a rule, do not sing. The mechanism of their vocal apparatus is the same as that of the males, though with a weaker muscularity; and they are not wanting in ability to give melodious and vigorous expression to the exuberance of their life, but they seem to have lost the habit, or to be without the disposition to do so. Some authors, with Daines Barrington and Darwin, regard their non-inclination to sing as a mark of prudence; for it would be dangerous for them to make themselves conspicuous during the breeding-season, and direct the attention of enemies to their nests with their precious contents. But some other authors suggest, and I am inclined to agree with them, that they are restrained by a feminine reserve. The knowl-

edge that the ardor of the male can be stimulated by indifference and inflamed to fury by resistance, prompts the female to practice all the arts of coquetry, of which Mantegazza says: "No woman can surpass the wonderful refinement with which a female canary-bird will offer a seeming of opposition to the passion of the male. All the numerous arts with which the world of women can conceal a 'yes' under a 'no' are as nothing compared with the arrant coquetry, the dissembled efforts to escape, the snappings and bitings, and the thousand tricks of the females of animals." Brehm says that the male finds in the female those desirable and attractive qualities that are wanting in himself. He seeks the opposite to himself with the force of a chemical element. A loud singing by the female would be as unpleasant to him as a beard on the face of a woman would be to a man. According to an Eastern proverb, man makes love with his speech, woman by her attitude and bearing. Among the feathered races, whose love-life is more largely and intensively developed than that of any other of the families of animals, the female perceives, feels, and knows that a discreet graciousness, a quiet power, and unobtrusive yet expressive, tender, and gentle manifestations, are attractions that operate irresistibly upon the male, and she therefore adopts them in her demeanor toward her suitor. Toussenel remarks: "Song is also given to the female; and, if she makes no use of the faculty, it is because she knows how to do more and better than to sing. She, as well as her brother, has gone through a course of music in her youth, and has cultivated her taste with the years. This cultivation, in fact, filled a need of both birds, for through it the female has become qualified to appreciate the charm of the elegies that are to be sighed out to her, and to award to the most worthy minstrel the prize for his song. The females know well enough how to express themselves in the language of passion when fancy inspires them to it or solitude condemns them to it." Fischer says that female birds begin at the same time with the males to twitter in the first practice of song, although they never pass beyond the stage of blundering at it. Bechstein remarks that the females of the canary-bird, bull-finch, robin, and lark utter a melodious song, particularly in widowhood. Darwin suggests that in some of these cases of female songsters the habit of singing may be ascribed to the fact that the birds are so well cared for and are captive; for such conditions are most likely to disturb all the functions connected with reproduction. Numerous examples have been mentioned of the partial transmission of secondary characteristics of the male to the female; and it is not, therefore, very surprising to find that the females of a few species also possess a fully developed and active faculty of singing. I will only add to these facts that even for a repressed exercise, and with a restricted muscular activity, a force and a proper organ are requisite, and that therefore the gently modulated, muffled sounds, the peeping, whispering, clucking, smacking, and cooing, with which the females respond

to the persuasions of the male, control their young, and otherwise express themselves, require a vocal apparatus similar to that of the male, which shall not be stunted by non-use. Instead of regarding, as Darwin did, the singing organs of female birds as an instance of the partial but useless transmission of secondary male characteristics to the female, I think we might now plausibly consider it a transmission in undiminished perfection of a faculty generally characteristic of both, but which is most freely exercised in the male on account of its relation to the most important act of his life, and hence to the maintenance of the species.

Singing out of rivalry finds an explanation in the disposition of the exultant songster to show himself off and to surpass others. If this exultant feeling is wanting, as, for instance, when it is depressed by some uncomfortable condition, the emulative singing stops. Hence, freshly-caught birds are songless in the cage, as are also males when several of them are confined together. In these cases the birds are pining for their lost freedom, or are suffering from the feeling of being crowded or hampered in their movements.

Domesticated birds sing also from a kind of gratitude to please their master, after they have discovered that he likes their songs, and the act produces in return a wholesome effect upon them. Under such influences, they sing all through the year, and more than they would do in freedom. I have had the opportunity of making a remarkable observation which shows that singing-birds desire the notice and applause of their attendant, and are affected by them. I had a yellow thrush (*Turdus saxatilis*), taken from the nest, which had become quite tame and confiding. Its cage hung behind the window-curtain of my study, and this adjoined my bedroom. I sometimes heard early in the morning a clear, melodious cock-crowing that seemed to come from a distant barn-yard. I thought of everything to which I might attribute it except my bird, which had never indulged in anything but the simplest song when I was present; but I soon found out his trick. Having risen early one morning and gone into the study while the bird's head was still hidden under his wing, I sat still in a farther corner of the room till matters began to get lively in the cage. Unobserved by my pet, I could see him through the folds of the curtain stretch out his wings and one foot, and plume himself. Then he found his voice and sounded out the cock-crow which I had heard so often from my bedroom without suspecting its real origin. Had I not seen the bird's mouth open and his throat vibrating, I should still have thought the sound came from a distance. Suddenly I stepped behind the curtain, when the bird, perceiving me, broke off at once in the midst of his crowing—a thing he had never done when I appeared as a witness to his ordinary singing—and fluttered timorously around as if he had done something wrong. I went out from the room and waited near, but the bird did not crow any more, nor again for two days afterward.

Then he ventured upon a repetition of his exercise before anything had moved in his neighborhood. I opened the door in the midst of his practice and he stopped, and he never would crow when any one was present. There is nothing particularly remarkable in the crowing of itself, for many birds imitate the sounds made by other animals. The curious fact about this circumstance was, that the bird would not crow in my presence, and would always stop when any one appeared to witness his exercise. There is no evidence that he had ever had an unpleasant experience in connection with crowing. His conduct must therefore be attributed to a kind of feeling of shame, or to a sense of the unfitness of that method of expression to a bird of his character and standing. Have we not in this another proof of the possession by animals of a psychical quality which it has been usual to regard as peculiarly and distinctively human?—*Translated for the Popular Science Monthly from Kosmos.*

SKETCH OF SIR DAVID BREWSTER.

THE contributions of Sir David Brewster to the progress of science were principally connected with his researches in optical properties and phenomena; and many of his discoveries in this line were almost immediately turned to practical use. He also did a wholesome work in diffusing knowledge and awakening interest in scientific subjects by the publication of his popular and readable but accurate and carefully prepared books.

Sir DAVID BREWSTER was born at Jedburgh, Scotland, December 11, 1781. His father was rector of the grammar-school, and a teacher of considerable reputation, whom neighborhood fame characterized as "the best Latin scholar and the quickest temper in Scotland"; but he was kindly withal. It was intended that David should become a minister, and he was sent to the University of Edinburgh, to be educated with a view to that profession, when only twelve years old. His tastes had, however, even before this time, turned into another direction. It is recorded of his earlier school-days that, though he was never seen to pore over his books like the other boys, he always had his lessons, kept a prominent place in his classes, and was frequently applied to by his fellow-pupils for assistance. And it was in the days of his childhood "that a dilapidated pane of glass in an upper window of his father's house produced the inquiring thoughts which led him afterward to search into the mysteries of refracted light."

He had become acquainted with James Veitch, of Inchbonny, half a mile from Jedburgh, whom Sir Walter Scott has mentioned as a "self-taught philosopher, astronomer, and mathematician." Veitch

was a plow-maker by trade, but was well versed in astronomical calculations and observations, having been the first discoverer of the great comet of 1811, and was in his most congenial pursuit when he was making telescopes, a work to which he brought much mechanical skill and scientific accuracy. His "scientific workshop," on the Jedburgh turnpike, "became a gathering-place for all the young men of intelligence in the neighborhood, most of them being in training for the ministry, for medicine, and other liberal pursuits. They had lessons in mathematics and mechanics, but especially in the favorite science of astronomy. The telescopes were tested in the day-time by the eyes of the birds perching on the topmost branches of the 'King of the Wood,' a noble relic of the past forest days, about half a mile from Inchbonny. When the bright sparkle of the bird's eye was distinctly visible by day, James Veitch's specula and lenses were considered fit to show the glories of the sky by night." David "was the very youngest," says his daughter, Mrs. Gordon, from whose book * we borrow our anecdotes, "of the quaint and varied group. When he began his visits I do not know, but we find that at the age of ten he finished the construction of a telescope at Inchbonny, which had engaged his attention at a very early period, and at which he worked indefatigably, visiting the workshop daily, and often remaining till the dark hours of midnight to see the starry wonders and test the powers of the telescopes they had been making."

Brewster gave faithful attention at the university to the studies which were assigned to him, having no intention as yet, nor for a considerable time afterward, to allow them to be superseded by any other. Yet all the time we find scientific questions prominent in his thoughts, and growing in interest to him. At every holiday he would make the journey to his home, a distance of forty-five miles, on foot, and then, before the day had ended, of another half mile to Inchbonny, to have a scientific chat with his friend Veitch. His letters to Veitch during this period are frequent, and full of references to scientific questions and scientific men. He is making an electrical machine, and tells of all his experiments and difficulties; he has made a map of the stars near our planet, and offers suggestions about grinding speculums; he is greatly satisfied with his telescope, to which, or any of Veitch's instruments, the great Newtonian reflector at the observatory can no more be compared than "a dirty common refractor with a fine achromatic telescope"; and he describes how a galvanic column may be made by combining copper or silver coins and pieces of tin or zinc with disks of card or leather soaked in water. These things were much more novel in those days than they are now. "He had," says his daughter, "a sincere attachment to the principles and constitution of the Established Church of Scotland, and a thorough acceptance of her doctrinal standards," and was duly licensed to preach. His first ser-

* "Home-Life of Sir David Brewster," Edinburgh, 1869.

mon was preached in the West Kirk of Edinburgh, one of the largest churches in Scotland, before an unusually crowded congregation; and he preached frequently for some time afterward. His ministrations "seem always to have been most acceptable from the beauty and earnestness of his style, and his well-known gift of creating interest out of the driest subjects." But he was excessively nervous, and his efforts were attended with intense suffering, in the shape of a nervous faintness, which only occurred when he was making a public appearance. For this reason he finally desisted from preaching.

His regular philosophical studies began in 1799, when, at the suggestion of his friend Brougham, he repeated Newton's experiments in the inflection of light, and in connection with them made his first discovery. His after-life was one of almost uninterrupted research. His investigations were to a large extent parallel with those which Malus and Fresnel and others were carrying on during the same period in France, and in some cases room was left for question as to priority of discovery. But in no case is Brewster's claim to independence in research and originality impaired. Professor Forbes has summarized the most important subjects of Brewster's inquiries at this time, as the laws of polarization by reflection and refraction, and other quantitative laws of phenomena; the discovery of the polarizing structure induced by heat and pressure; the discovery of crystals with two axes of double refraction, and many of the laws of their phenomena, including the connection of optical structure and crystalline forms; the laws of metallic refraction, and experiments on the absorption of light. Of his discoveries, primary importance belongs to those of the connection between the refractive index and the polarizing angle, of biaxial crystals, and of the production of double refraction by irregular heating.

In 1816 he devised the kaleidoscope, which became at once very popular, and spread his name widely among all classes of people. The patent which he took out for it was of little value to him, for the authorized manufacturers seem to have wholly failed to supply the demand for the instruments, and the device was speedily patented by enterprising adventurers who made their fortunes out of it. He afterward made earnest and long-continued efforts to promote reforms in the patent laws that should make them more just to inventors.

Several years later, in 1849–'50, he perfected the stereoscope, the principle of which had been discovered and applied by Wheatstone in 1838. Wheatstone employed mirrors to effect the merging of the binocular pictures into one; Brewster substituted lenses for the mirrors, and gave us the instrument substantially as it is.

For the improvements that were made in lighthouses during the second decade of this century, the credit must be divided between Brewster and the Frenchman Fresnel. Both worked independently, and arrived in some cases at nearly identical results. Sometimes Brewster, sometimes the Frenchman, was ahead on a particular point.

Their works have outlived them, and commercial men and sailors have reason every day to bless the memory of both; and of the Englishman, his successor as Principal of the University of Edinburgh has said with truth, "Every lighthouse that burns round the shores of the British Empire is a shining witness to the usefulness of Brewster's life."

Hardly less important in forwarding the progress of science than his direct labors, was the part which Brewster took in the formation of the British Association for the Advancement of Science. "The decline of science" had been much talked of among scientific men for several years, and much thought had been given to the consideration of means of reviving scientific interest, when Brewster, reviewing in the "Quarterly Review" a work on the subject by Babbage, proposed "an association of our nobility, clergy, gentry, and philosophers," as that which "can alone draw the attention of the sovereign and the nation to this blot upon its fame." In the course of a few succeeding months, the plan of the British Association met with general acceptance, and was soon thoroughly matured; and the first meeting, held at York, in September, 1831, at which three hundred and twenty-five members enrolled their names, and a zeal for science was excited "which will not soon subside," was attended with a success that "infinitely surpassed all our most sanguine expectations." At the twentieth meeting of the Association, held in Edinburgh in 1850, Brewster was the president.

Brewster's literary activity kept pace with his scientific work. It was begun at the same time, in 1799, when he became a regular contributor to the "Edinburgh Magazine," and was continued in various shapes as he had new investigations of his own to describe, the work of others or any marked progress in science to review, or views of his own to publish on the topics which from time to time became prominent in the various regions of thought. In 1807, acting upon a casual hint given him by the Rev. Mr. Ramsay, of Tranent, of how much a good and thorough encyclopædia was needed, he began the "Edinburgh Encyclopædia," which was not completed till 1830. In connection with this work we find him, just after the first two numbers had been published, writing to his friend Veitch for a drawing and description of his new plow, to be inserted in the article "Agriculture," and mentioning an intention also "to publish in the same article a curious paper by Mr. Jefferson, President of the United States, on a plow-ear which offers the least possible resistance." This work was strongest in the scientific department, to which the editor contributed many of the most valuable articles. Like all such works requiring a combination of many minds, it was difficult to manage, and cost Brewster much labor, vexation, and anxiety. He was afterward a contributor to the "Encyclopædia Britannica," to the seventh and eighth editions of which he furnished articles on hydrodynamics, magnetism, microscope, op-

tics, stereoscope, voltaic electricity, etc. In 1819 he assisted in establishing the "Edinburgh Philosophical Journal," afterward the "Edinburgh Journal of Science," which took the place of the "Edinburgh Magazine," and subsequently became its sole editor. He also had a part in founding the "North British Review," and was a regular contributor to it, having been the author of seventy-five articles that appeared in it. In 1838 he was appointed Principal of the United Colleges of St. Salvator and St. Leonard, St. Andrews, and in 1859 became Principal of the University of Edinburgh. His life at St. Andrews was checkered by transient difficulties that grew out of his excessively nervous temperament. At Edinburgh, a minute recorded by the University Court after his death described him as "one whose warm interest in the university never abated to the last, and who, on the many occasions on which he presided over their deliberations, or was associated with them in business, evinced the sagacity of a clear and disciplined intellect and the courtesy of a kind and Christian gentleman, while each member of it feels that by his death he has lost a valued and respected friend."

In 1825 Brewster was made a corresponding member of the French Institute. From this time, says Mrs. Gordon, "honors crowded in so rapidly upon him that, except any of special interest, it would be tedious to enumerate them in their order and succession. Suffice it to say that the large book in which the letters, diplomas, burgess-tickets, announcements of medals, etc., are collected is a remarkable one for size and value. The large towns of Switzerland, France, Germany, Holland, Italy, Russia, Belgium, Portugal, Austria, Sweden and Norway, South Africa, Antigua, the various States of America, besides the towns and universities of England, Scotland, and Ireland, all contributed their quota of honors to this man of research and industry. A cape received his name in the Arctic regions, a river in the Antarctic, and a new plant discovered by Dr. Muellin in Australia was named *Cassia Brewsteri*. He received, besides the Copley, Rumford, and Royal medals, two Keith medals from the Royal Society of Edinburgh, two from the French Institute, one from Denmark, one from the Société Française de Photographie, and various others; of some of the most valuable of these, duplicates were sent to him, one of gold, which he turned into plate, and a fac-simile of frosted silver—all being preserved as heirlooms. He was knighted in 1831, the year of the first meeting of the British Association, and also received the Hanoverian Order of the Guelph."

In examining Mrs. Gordon's most interesting work we have been struck with the variety of subjects in which Sir David Brewster was interested, and of the discussions in which he took part. We can only mention some of them, as we find them laid down in the table of contents. Connected with his researches on light were all matters relating to photography and color-blindness, which was strikingly exemplified

in his friend Dalton, and on which he wrote an article for the "North British Review." In church matters, he made one of the first suggestions that led to the formation of the Evangelical Alliance; he took a prominent part in the disruption of the Church of Scotland, and was one of the founders of the Free Church—at the cost of much tribulation and an unsuccessful suit to eject him from his chair as Principal of St. Andrews; and throughout his life he stoutly upheld the harmony between the results of scientific investigation and his orthodox religious faith. Then we find him a warm believer in the authenticity of Mr. Macpherson's "Poems of Ossian"; an interested spectator of the beginnings of the electric telegraph; putting aside his dislike to prominent positions to act as President of the Peace Congress in 1851; discussing the doctrine of the plurality of worlds; investigating the spirit-rappings; and finally inquiring into every new phenomenon, and busying himself with everything that could contribute to the advancement of knowledge or the benefit of mankind.

The reform of abuses was one of the passions of his life. For three years he lived at Belleville, on the estate of his wife's sister, and had a full field for gratifying it on a property which had been for many years "too indulgently superintended." He "awakened a warm and abiding attachment among the majority of the Highland tenantry, who anticipated with delight the time, which never came, when he might be their landlord in very deed. They were proud of his scientific fame, which indeed spread far and near. I remember four working-men coming a considerable distance from Strathspey, with the petition that they might see the stars through his telescope; while on another occasion a poor man brought his cow a weary long journey over the hills, that the great optician might examine her eyes, and prescribe for her deficiencies of sight; and all, as was ever his wont, were received courteously, and had their questions not only answered, but answered so clearly and patiently that the subjects were made perfectly intelligible and interesting."

"All who knew him," says Miss Forbes, afterward the wife of the Rev. Canon Harford Battersby, "will, I am sure, unite in testifying to his readiness to explain, it might be, the simplest principles of a science to some insignificant person, and the wonderful enjoyment he seemed to find in so doing—quite as much, indeed, as in talking of some of his latest discoveries to the most learned—if only his listener were thoroughly interested and anxious to learn." One person, "himself the possessor of genial gifts and genius," is quoted as having remarked, "When I have been with other great men, I go away saying, 'What clever fellows *they* are!' but when I am with Sir David Brewster, I say, 'What a clever fellow *I* am!'" Miss Horsbrugh, whose tutor he was from 1799 to 1804, gives a pleasant picture of him as a great favorite with the children, especially with those who could enter

into his own pursuits, and fond of experimenting before them, particularly with his electrical machine. She remembers the starts and shocks she received, and also being occasionally left alone in the dark, when Mr. Brewster would appear among them with his outstretched hand and fingers all in an apparent blaze from phosphorus. Some of his scientific practices greatly incensed Mrs. Dickson, the housekeeper, who declared that he would never rest till he had set the house on fire.

His principal literary works, many of which have obtained a wide popular circulation, are his "Life of Sir Isaac Newton," published in Murray's "Family Library," and the larger memoirs embodying the fruits of twenty years of investigation, published in 1855; his notes and introduction to Legendre's "Geometry" (1824); his "Treatise on Optics" (1831); "Letters on Natural Magic" (1831); "The Martyrs of Science" (1841); and "More Worlds than One" (1854). The list of his briefer scientific papers and miscellaneous writings includes, besides the seventy-five articles contributed to the "North British Review," three hundred and fifteen titles.

A monition of the waning of his vital powers came to Sir David in the spring of 1867, when he lost consciousness in a fainting-fit in his class-room at the university. He attended the British Association at Dundee, in September of the same year, and had another fainting-fit, after enduring the crowd and heat of the public assembly. He returned to his home, never to leave it again, but had to occupy himself with the papers of the forged Pascal-Newton correspondence, and to ward off from Newton's memory the blot which it was attempted to put upon it. This was the last act of his scientific and literary career. "He went straight from this controversy into the gathering silences," and died, at Allerly, Melrose, February 10, 1868.

CORRESPONDENCE.

"QUEER FLOWERS."

Messrs. Editors:

IN reading the interesting article by Grant Allen on "Queer Flowers," in the December number of this "Monthly," I observe some statements concerning the fig which observation here in California, where the tree is very common and grows luxuriantly, does not confirm. In the first place, the *caprifico* does not, so far as I am aware, grow here at all. We realize, therefore, a condition the same as though it had "become extinct"; and yet the supply of figs—"best Eleme in layers"—has not "ceased entirely." On the contrary, figs here in the city are a drug, and are literally trodden under foot of men on the sidewalks overhung by the trees; and in the country they lie rotting on the ground in thousands upon thousands for lack of the labor and care necessary for their marketing or preservation. This looks as though the "true figs" were not "dependent upon it (the *caprifico*) for pollen," as the writer states; and I am inclined to think that the "extraordinary and complicated cross-relationship" to which, according to Mr. Allen, the flowers of the fig owe their fertilization, is a myth, and, on the strength of the argument *a posteriori* alone, should be relegated to books for the nursery.

But, in addition to this, let us look at the (literally) internal evidence afforded by the fig itself against this mythical cross-relationship. The flowers of the fig, growing as stated on the inside of the hollow stalk or receptacle, which forms when ripe the main bulk of what is popularly known as a fig, are of two kinds, viz., male and female; that is to say, the male, or pollen-bearing organs (stamens), and the female, or seed-bearing organs (pistils), are borne on separate stalks, just as in the melon and cucumber. But while in the last-named plants the different flowers are placed at some distance apart on the vine, here they are crowded together in the hollow receptacle in close contact and in almost every conceivable relative position, above, below, and on all sides; and the hollow receptacle is all but completely closed by an irregular fringe of metamorphosed bracts which surround the eye ("hole," by courtesy) in the distal end. They (the flowers) are, therefore, in the best possible condition for self-fertilization, without any external aid from insects. The fig, in fact, presents in its *synconium* an analogy to the perfect *Cleistogamous flowers* found scattered through several orders and genera, which, although containing both stamens and pistils, do not open out or bloom, yet nevertheless, producing abundance of seeds, prove themselves to be self-fertile.

Note here, however, that I do not assert that the flowers of the fig are generally or in any great number fertile; indeed, I have reasons to doubt this being so, for I have yet to see the first seedling fig-tree. And yet, from the great number of seeds (fruits?) falling on the ground and being covered up every season, it would seem almost certain that, if they were generally fertile, at least a few would germinate; and this brings me to another statement of our talented writer, which will bear examination before acceptance, viz.: " . . . *as the figs won't properly swell without fertilization*, . . . and for this reason the Italian peasants hang on the tree small branches of the *caprifico* . . . at the moment when the eye of the fig opens, and *so shows that they* (*the flowers*) *are ready to be fertilized.* The wasps . . . enter the figs at once and there set the little hard seeds, *on whose fertilization the pulpy part of the fig begins to swell.*" The italics are mine.

Is it certain that the swelling or ripening of the fig is at all dependent on the fertilization of its contained flowers or any of them? The pineapple presents a case in point which negatives the proposition, at least as a general one. Here the flowers are on the outside of a simple axis, in form of a spike. The axis continues growing beyond the spike of flowers, and may be cut off and rooted to form a new plant; in fact, this is the common and, I believe, the only mode of its propagation. Now, the pineapple as a fruit is formed by the axis, together with the surrounding and constituent flowers, bracts, etc., swelling and blending together in ripening into a fleshy, juicy mass, *but the flowers are sterile and seedless.* The plantain and banana likewise both ripen their fruits without the fertilization of their seeds. Although I am not in possession of conclusive evidence on this point, I am disposed to think, from some facts already stated, that the fig (through long continued propagation by layers or cuttings?) is approaching the condition of a seedless plant. Be this as it may, it has, I think, been shown that the "fig-wasp" may be stricken out of the account as surplusage, together with the pollen of the *caprifico*, with the result of no fewer figs and a nearer approach to the true story of the *Ficus carica.*

GEORGE PYBURN.

SACRAMENTO, CALIFORNIA, *December*, 1884.

A NOVEL PHENOMENON.

Messrs. Editors:

WHILE several students of the University of Nebraska were geologizing in an outcrop of the Dakota group, situated in the western portion of Lancaster County, Nebraska, about thirteen miles west of Lincoln, they brought to light a curious freak of Nature. This was a leaf-impression, or rather the fragment of an impression, that preserved the green color which it wore several million years ago at the commencement of the Cretaceous period in geological time.

The deposit in which the leaf was found is a maroon-tinted sandstone, quite soft when first quarried, but solidifying rapidly after exposure to the atmosphere. The total thickness of the layers which outcrop at this point is about forty feet. The true dip is too slight to be accurately measured.

None of the layers of sandstone—and this is the sole kind of rock found in the Dakota group of Lancaster County—are of the peculiar reddish shade except that which contains the leaves. This layer averages nine inches in thickness, and is situated near the upper surface of the group.

The leaf-impressions obtained were many of them very beautiful and complete, representing various species of *Juglans*, *Laurus*, *Liquidambar*, *Salix*, and *Quercus*, with many others. They were very numerous, as many as two thousand specimens being obtained in a few hours.

The unique green leaf-fragment was too small to allow of successfully determining its genus or species. It is probably *Laurus*, however, since it was found in a mass containing impressions of *Laurea* almost exclusively.

C. G. MCMILLAN.

1503 H STREET, LINCOLN, NEBRASKA, *October* 23, 1884.

EDITOR'S TABLE.

"*MIND AS A SOCIAL FACTOR.*"

THIS is the title of an article contributed by Mr. Lester F. Ward to the quarterly periodical "Mind." Mr. Ward, as is well known, is the author of "Dynamic Sociology," which contains an elaborate attack, with all the weapons of science and philosophy, upon the doctrine of *laissez faire*, as it is termed, or the policy of meddling less, and leaving things social more to their own natural courses. One of the chief arguments of the book is reproduced in this paper, and, as the subject is important, we propose briefly to examine it, and offer some objections to the view taken.

Mr. Ward argues that the *laissez-faire* school of thinkers fail to recognize the true office of intelligence in controlling social activities and accomplishing social ends. He begins by stating that they make their constant appeal to Nature, to the laws of Nature, and the method of Nature, as all-sufficient for working out social good, so that man's agency in the matter, where not mischievous, is superfluous. He then proceeds to show that this view leaves out of account the most momentous fact in the history of this world, namely, the advent of mind as a controlling agency in terrestrial affairs. He does not deny that there is, or has been, a method of Nature, and that in past times it has accomplished great things. He recognizes that it worked on, by the law of evolution, through vast periods, reaching higher and higher stages, until at length was ushered in the grand era of mind. A new order of things was now initiated. In the matured epoch of mind, advanced human intelligence took control of the planet. Its forces were subjugated and pressed into human service. The old method of Nature, by which progress came through destruction, wastefulness, and cruelty, gave place to a new method, that of art, which is the antithesis of Nature, and of humane protection of the weak instead of their remorseless destruction. The new era of mind was marked by inventions, constructions, and industries, by the rise of institutions of justice and beneficence, of governments, civilizations, and all the regulative agencies of human affairs.

Mr. Ward then takes the ground that those who still talk of following

the method of Nature, and deferring to natural laws, quite overlook the meaning of these supreme facts, and seem unaware of the new dispensation upon which the world has entered. He makes "The open charge that the modern scientific philosophers fail to recognize the true value of the *psychic factor*"; and again he says, "The *laissez-faire* doctrine fails to recognize that, in the development of mind, a virtually *new power* was introduced into the world."

Mr. Ward must not be here taken too literally, for certainly the *laissez-faire* people have some appreciation of mind as a factor in social progress. He can only mean that they have a very imperfect conception of it, because their do-nothing method does not imply the need of it. It is desirable, however, that we have first of all a correct idea of what this policy is. And here we must protest against some of Mr. Ward's extreme assertions. He declares that "the *laissez-faire* doctrine is a gospel of inaction"; and that, to be consistent, "its advocates must condemn all interference with physical laws and natural forces." He says they hold that "all schemes of social reform are unscientific"; that "they condemn all attempts to protect the weak, whether by private or public methods"; and that "in government every attempt to improve the condition of the state is condemned and denounced." These are unwarrantable exaggerations. The representatives of *laissez faire* have as much at heart the good of society, and work as hard to secure it, as any other class. It is not true that they hold to the method of Nature in social life in any such sense as absolves men from active effort in the direction of social improvement. Mr. Herbert Spencer is probably, as Mr. Ward himself recognizes, the leading living representative of the *laissez-faire* school, and he repeatedly, explicitly, and consistently in his earlier as in his later works, enforces the obligation of protecting the weak by sympathetic and discriminating aid, and he ever maintains that there is no more commendable or admirable social service than to help the weak and poor to help themselves. Moreover, his works throughout, from first to last, make imperative demands for radical and comprehensive scientific reforms in the policy of government with respect to the administration of social affairs. This is the common and distinctive ground of the *laissez-faire* school; and the question here is simply, What value does this give to "mind as a social factor"?

The believers in *laissez faire*, or in leaving things social more to themselves, hold that there is a natural order in the social state which has not been superseded or antiquated by the coming of man upon the stage, and that there are natural laws of human society, the understanding of which is the first condition of all real social advancement. They maintain that blind and ignorant intermeddling with these laws has been and is still productive of far more evil than good, and that therefore the first grand task of social science is their full and systematic elucidation, while it becomes the highest duty of education to disseminate knowledge of the laws thus gained. But the disentangling of social phenomena and the clear working out of their underlying principles are certainly among the highest efforts of the human mind. As yet we have only partial glimpses of these laws, insufficient for full guidance—but little more than sufficient to attest their existence. The most profound and fruitful intellectual work for generations to come is to be done here. Can it be said that those who contribute to the solution of these formidable social problems—so fundamental to practical success in social undertakings—are open to the charge of disparaging the function of "mind as a social factor"? On the contrary, is it not they who most eminently honor it? Mr. Ward not only admits that there are social laws which

it is perilous not to know, but he recognizes that this is the essential fact of the *laissez-faire* view. He says: "What, then, remains of the *laissez-faire* doctrine? Nothing but this: that it is useless, and may be dangerous, to control natural forces until their character is at first well understood." "Nothing but this"! And is the thorough understanding of social forces in their complicated actions and reactions really so trivial a thing? We have been wont to consider sociology — the true social science inductively based and deductively verified as dependent for its establishment upon all other sciences—as the most intricate and difficult of all, as but just fairly reached in the progress of the human intellect, and as requiring the highest range of intelligence for its successful investigation; and, if so, then by insisting that the recognition and understanding of social laws is an indispensable prerequisite to safe and effective social action, the believers in *laissez faire* put the highest premium upon intelligence, both as an instrument of the establishment of truth and a means of general education.

Again, and in another aspect, *laissez faire* implies, and by its nature provides for the best mental development. Its advocates insist that, in dealing with social subjects, there should be more reliance upon individual action, more personal responsibility, more spontaneous co-operation, and larger demands upon private enterprise. But this view obviously makes intelligence the controlling factor in social life, for successful self-direction is only possible with increasing knowledge, keener discrimination, and greater mental activity on the part of the actors. Not only is the highest pressure thus put upon individuals, but the conditions are favorable for what is most needed — self-improvement. There is no such thing as corporate intelligence, it is ever an individual thing. Whatever view we take of the nature of mind, it is essentially a personal attribute. If we hold it to be a special divine gift, it is still a gift to the individual primarily for individual uses. If we hold that mind has been naturally evolved, its development has come through individual experiences as a preparation for the care of individual interests. On any view mind is a personal endowment, its aptitudes a personal inheritance, its unfolding a result of personal exertion, and its exercise a matter of personal responsibility. The system, therefore, which calls for greater self-reliance and more independent self-direction, must not only assign a prerogative value to the social function of mind, but it adopts the only possible means of attaining its highest advantages. If it be said that the idea of sufficient general intelligence for social guidance is a chimera, that only shows that the *laissez-faire* view overestimates what mind can be made to do.

Can it be for a moment maintained that the opposite school, which favors corporate and wholesale social regulation, the tendency of which is to paralyze the incentives to personal effort, places a higher estimate upon "mind as a social factor" than that which insists that citizens should rely more upon themselves and not shirk their individual duties? And what less is this higher trust in state compulsion as against voluntary action than a virtual abdication of the function of intelligence in the control of social activities? Working by deputy is assuredly not the best way of securing intelligent action. Is it too much to say that the system of coercive regulation flourishes best in ignorance? Ignorant constituencies clamor for endless legislative intermeddling, and equally ignorant representatives give them what they want. Notwithstanding all Mr. Ward says about the ascendency of *laissez-faire* ideas, do they control the public policy, or are they not limited to a few teachers who are generally disparaged as mere speculative *doctrinaires*? Are the members

of Congress and of the State Legislatures and their accompanying lobbyists, who devote themselves to the regulation of social affairs, well-instructed men who have availed themselves of what there is of social science, or are they not as a class distinguished by their ignorance and contempt of the subject? Not much knowledge is required to make laws; much to make them wisely and intelligently. Laws of every sort for the control of society are blindly enacted, amended, repealed, or left to become dead letters, while only so much of legislation gets executed as happens to conform to the actual state of general intelligence. Such hap-hazard, ill-adapted action does not give a very exalted idea of "mind as a social factor."

THE RELATION OF SCIENCE TO CULTURE.

CULTURE may, we think, be properly described as that knowledge or training which is essential to, at least, a provisional completeness of human nature. To secure such provisional completeness all the lines of a normal human activity must be more or less occupied, all the permanent faculties and capacities of the normal human intellect must have a certain exercise and development, and so be made channels of happiness and of usefulness to the individual. Viewing the matter in this light, we see that while this or that special piece of knowledge may not be necessary to culture, each *branch* of knowledge and of thought must bring some contribution to it. Culture implies understanding, appreciation, and some power of action. To have a mind wholly unexercised in some important region or regions of knowledge, and therefore wholly incapable of appreciating what may thence be drawn for the general nourishment of thought and advancement of civilization, is to have a culture so far incomplete; and an incomplete culture is, according to our present definition, the negation of culture. It may be that in the case of no human being is our idea of culture fully realized; still, for all that, the idea may be a good one. Manifestly, the aim of culture is to give such perfection to human nature as it is capable of—to develop not one set of faculties only, but all faculties; and so far it is correct to speak of (realized) culture as "a provisional completeness of human nature."

It may, perhaps, be objected by some that the definition of culture here given is calculated to lend aid and comfort to that spirit of dilettanteism which has proved itself so serious an impediment in the past to the progress of true knowledge. Under the pretext, it will be said, of aiming at some kind of completeness of intellectual outfit, many will be found contenting themselves with mere surface knowledge, and shirking all the hard work inseparable from a proper grounding in any one branch of study. To this we can only reply that the requirements of our definition would not really be met by such a course as this, and that nothing would be easier than to expose the charlatan who, not only knew nothing well, but had no proper measure of his own ignorance. A large part of culture, as we here understand it, consists in having some due appreciation of the extent and importance of those fields of knowledge which we have not been able to make our own. We recognize the man of culture not less by his diffidence in regard to those things he has not mastered, and upon which he does not venture even to have an opinion, than by the confidence and precision with which he moves in subjects that he has more or less made his own. Show us the man who, on the strength of a little general reading, will express opinions right and left, or who argues deductively, with reckless confidence, from a few general principles settled in his own mind, and we shall show you one who has never risen to the conception of culture which we are here en-

deavoring to set forth. "The fear of the Lord," says an admirable proverb, "is the beginning of wisdom"; and the first lesson in culture is the correction of that error to which, as Bacon has pointed out, all untutored minds are prone, of supposing in nature a greater simplicity than really exists.

Now, the contribution which science brings to culture is this:

1. It imparts actual knowledge of the condition and constitution of the external world.

2. It trains the observing and reasoning faculties.

3. It imparts a knowledge of its own methods, and by so doing gives the mind a new consciousness of its powers; for the methods of science are simply the labor-saving methods of the mind itself.

We see, therefore, its relation to culture. That wholeness of the mind of which we have spoken is manifestly incompatible with gross ignorance and error in regard to the source whence all sense-impressions flow. It is not culture to be floundering amid hopelessly erroneous hypotheses, nor to see things only with the untrained eye of sense instead of with the inward eye of instructed reason. Culture—intellectual wholeness—requires that we should see the world as those see it who have studied its phenomena and laws; not that we should know all that each specialist knows—a manifest impossibility—but that we should in a general way know what report has been brought from each great field of inquiry. So in the days of Columbus culture did not require that each man should visit the new continent for himself; but culture did require that each should know that a new continent had been discovered, and what its general features were, so far as it had been explored. The man of culture to-day should be able to speak of the world as it is now known to be, not as it was supposed to be fifty, or a hundred, or two hundred years ago.

Secondly, science trains the observing and reasoning faculties. The habit of direct observation of Nature is one of the most important that any human being can acquire. By bringing the observer into direct contact with Nature, it gives a healthy concreteness to his conceptions. He who misses this training in early life will not be likely to make good the deficiency in later years. Many men, who have naturally good reasoning powers, find themselves condemned to more or less of intellectual sterility, simply because what we may call the fact-grasping faculty has never been developed in them. If they had materials to work with, they could do good work; but they have not the materials, and do not seem to know how to gather them. They live in a too attenuated air: like the ancestral ghosts whom Myrtle Hazard saw in her dream, they call for "breath! breath!"—the breath that no living soul need lack who will but go to Nature for a supply. It may be said, indeed, that a logical faculty without a strong sense for the concrete is a source of danger to its possessor, leading him afar on the seas of speculation, with no guide but a few charts and his own dead-reckoning. He who can observe Nature, on the other hand, is like the mariner who can "take the sun," and know his exact position from day to day. Many of the intellectual evils of the present time spring from the too wide-spread use of intellectual faculties untrained by the study of Nature, and therefore unchecked by any due sense of the complexities which the problems of life present. Science teaches caution; it teaches the paramount importance of verification, and creates not only a distrust of, but a certain lack of interest in, conclusions that have not been reached by proper methods, and which do not admit of verification. Scientific men, in general, it will be observed, are not revolutionary in their opinions; they work on patiently, and hate nothing so

much as premature production of results. They often have occasion to smile at the confidence with which mere theorizers undertake to tell the world what the whole significance of their work is.

The methods of science are, as we have said, the labor-saving devices of the human mind. They are the choicest and most precious results of the travail of the human intellect upon the phenomena of its environment. Not to know something of them is, in a wide sense, one of the worst forms of self-ignorance, for the intellect that has worked out and established these methods is not any individual intellect, but the intellect of the race. We are all entitled to our share in what the race has accomplished. And shall we supinely and ingloriously consent to be ignorant of the intellectual triumphs that the race has won? The man of culture must have a consciousness of his own best self, and must have it in his power to live his best habitually, and not be dependent upon critical occasions to reveal what his capacities are. The function of culture is to redeem us from the sway of chance, and make us fully masters of ourselves. We see, then, what it must be, from the point of view of culture, to know the ways of Science, and to be able to trace her shining footsteps along some of the grander paths of discovery. We see, too, what, from the same point of view, it must be not to know anything of all this, but to live in a world the phenomena of which never reflect back the light of law into the understanding, or convey any clear suggestion of the conquests which the human mind has achieved. To think that, not so long ago, this condition of mind was thought by many, yes, by most, quite compatible with "culture"! Times are changing, fortunately, and we trust that few men of intelligence are now to be found who would dispute our definition of culture as a certain provisional completeness of the human mind in the sum and development of its faculties, or who would deny that, to constitute such completeness, a liberal scientific training is wholly indispensable. Each of the points on which we have touched would admit, as every one can see, of much expansion; but we thought it well to present the general argument for once in this very summary form, reserving the liberty of returning to the subject and treating it in more detail as occasion may serve.

LITERARY NOTICES.

PRINCIPLES OF POLITICAL ECONOMY. By JOHN STUART MILL. Abridged, with Critical, Bibliographical, and Explanatory Notes, and a Sketch of the History of Political Economy, by J. LAURENCE LAUGHLIN, Ph. D., Assistant Professor of Political Economy in Harvard University. A Text-Book for Colleges. New York: D. Appleton & Co. Pp. 658. Price, $3.50.

PROBABLY the ablest systematic work produced by the modern English school of political economy is the comprehensive treatise of John Stuart Mill. It has been a good deal used in the colleges, but is in several respects imperfect as a text-book. Its two volumes are inconvenient, and the treatment unsuited for class-room purposes. Besides, it was published more than thirty years ago, and the progress of the science within that time has been such that certain parts of Mill's work will bear considerable abridgment, while other parts require modification and further development. Professor Laughlin, of Harvard University, has accordingly undertaken the task of revising the work, reducing it to a single volume and making various additions to it, which give greater prominence to important questions of the present time. The author also exercised his discretion in introducing such illustrations as shall better fit it for the use of American students, and he has also enriched it with a bibliography that will give it a special value for educational purposes. As this edition of Mill's "Political Economy" is now beyond doubt the best college text-book upon the subject, it is desirable that we should indi-

cate with some fullness of detail the nature of the modifications and additions that have been made.

On the "Wages Question," Mill's statement of the "Wages-Fund Theory" is supplemented by the results of the thinking started by Longe, Thornton, Walker, and Cairnes. The conclusion is still retained that the relation between numbers and that part of capital which is necessarily devoted to wages (although not absolutely fixed in amount) determines the average rate of wages, supposing that there is free competition among laborers. Then the adaptation of this theory to the facts of practical life, in which free competition does not exist between distinct occupations, is arrived at by introducing Mr. Cairnes's doctrine of non-competing groups in the discussion of the varying rates of wages in different employments. These additions are inserted so as to naturally supplement and closely connect with Mr. Mill's system, thus introducing the results of study in the generation since Mill wrote his two volumes. These parts are necessarily brief and condensed, but the reader is given references in foot-notes to the writers themselves, which he can consult as he goes on.

Mr. Mill included wages of superintendence under profits, and thereby gave some excuse for much of the wrong talk about a conflict of labor and capital. In this edition it is made apparent by Mill's own showing that wages of superintendence should be classed with other wages of labor, and so the high returns of managers are explained as arising from the same causes which influence the wages of other skilled laborers—the possession of a natural monopoly. This is only an extension of the doctrine of non-competing groups; and profit is then confined properly to interest for abstinence and insurance for risk.

Since Mr. Mill's day the modern form of socialism, whose essential doctrine is state help, has spread from France to Germany through the teachings of Marx and Lasalle, and pervaded our own country. A statement of their position is incorporated into the book, and Mr. Mill's later views on socialism, as expressed in his posthumous chapters (written in 1869), are printed in connection with his earlier views.

The chief weakness of Mr. Mill's book was undoubtedly his treatment of cost of production. The admirable study of Mr. Cairnes has cleared this ground, and the results of that work are given in this edition, so that the reader can get the right conception of this fundamental matter in connection with the remainder of the economic system. This in its turn then makes international trade, as expounded by Mr. Mill, more simple and more easily understood.

The whole lively discussion on bimetalism arose since Mill's day, although he touches somewhat on the double standard. His omission is filled by a considerable study on the experience of the United States since 1792. The history of that experience with gold and silver and the working of our legislation on this subject are stated and explained; and in the Appendix a bibliography of two pages for the subject in general is given.

Mr. Mill's book, of course, contained nothing treating of our own experiments in paper money, but much on English currency discussions. These latter have been omitted; and the experience of the province of Massachusetts, the issues of Continental currency, and the greenback issues from 1862 to resumption of specie payments in 1879, are considered with a view to the lessons that may be learned from this kind of currency.

International values presented unnecessary difficulties to the reader in the form it assumed under Mr. Mill's pen. This was largely omitted, and a very much simpler exposition given of the laws of reciprocal demand and supply, as a supplement to the previous exposition of value.

The connection of wages with prices and the doctrine of comparative cost as affecting foreign competition are added at some length in the chapter on foreign competition. The connection of wages with foreign competition had not risen in Mill's day to its present factitious importance in the vulgar mind.

Mr. Mill's (or rather Mrs. Mill's) chapter on the future of the laboring-classes was rambling and quite obsolete. An entirely new chapter was put in its place, pointing out the very considerable gain of the laboring-classes in wages during the last fifty years in England and America as disclosed

by the statistics. Then the devices of co-operation for giving the laborers a share in the profits of capital and the wages of superintendence, either in the form of distributive or productive co-operation, industrial partnerships, and people's banks, are described, and also the effect of peasant proprietorships on small owners of land in giving them a share of the "unearned increment."

Mr. Mill's chapter on protection was almost out of date; moreover, his own views on protection to infant industries had been more fully expressed in a letter which was inserted by the editor. The arguments concerning wages and the tariff, diversity of industries, and the effect of a tariff on prices, have been added at this place.

The illustrations have been modified so as to apply directly to the United States, as in case of the exchanges, international trade, etc. A marked feature of this edition is the striking use made of illustrative diagrams. The twenty-four maps or charts which bear especially on American conditions have been inserted in order the better to apply principles to the state of things directly about us. This method is of great importance. As many kinds of graphic representation as possible have been introduced. No other text-book on political economy exists which makes use of charts in this way. It both interests the pupil and makes statistics alive, and it stimulates a reader to a study of facts and to the verification of economic principles. The single chart No V is in itself an exposure of the folly of supposing that our railways are grasping monopolies; and chart No. X tells the whole story of the fluctuating value of silver at a glance. As a device in teaching, many small diagrams are used here and there, to show the abstract in the form of the concrete. For example, three concentric circles illustrate the relation between wealth, capital, and money. A good teacher will make others of his own.

Perhaps the most pressing practical difficulty to honest inquirers is a knowledge of books in this age of much publishing. An evident effort has been made throughout the whole work to meet this want by bibliographies. The editor seems to have been animated with an earnest purpose to unlock the results of study upon this subject to every reader, and to give him the knowledge of books which only a very laborious student in a large library could acquire. This was done first by supplying to the new edition the story of the growth of economic ideas and the existing body of laws, attended by the title and date of the books of each writer who figures in this story, so that not only past but living writers are classed in schools and their books given in that connection. Thus, any reader is able to select his additional reading with a clear idea of its tendency and position in regard to other systems. Then a brief list of the most important books in political economy, which would form a small but well-selected library for any teacher or student, has been given under the head of "Books for Consultation" (pp. 43–46). This list will be useful also while the reader is mastering his Mill.

But, after he has finished Mill's volume, bibliographies on various questions of the day are given, in order to furnish readers with the tools for further and special study. For example, in Book IV, Chapter V, p. 6, a list of books treating of industrial partnership is given; and, in Appendix I, bibliographies on our tariff history, bimetalism, and American shipping are given in more detail. Moreover, throughout the work the reader is put in the way of finding publications devoted to other or opposing views from those given in the text. This, it is believed, is a feature not found in any other text-book, and teaches men to compare views for the sake of truth—in short, to think, and not merely to absorb an authority.

In Appendix II, examination-questions will aid both student and teacher in estimating the extent of knowledge necessary to good work. These have been taken from Harvard papers or those set in English universities.

It will thus be seen that this new edition of Mill's work is a contribution to more thorough methods of teaching political economy, and aims at a breadth and liberality of treatment which are now imperatively demanded in the pursuit of this comprehensive and important science. The purpose of the book is to insure a mastery of the subject. The reader who follows all the references

given as he goes along will find several years of work in them; but, while gaining first a general knowledge of the system, he can then easily know where to go for more detailed study on special subjects. To an intelligent reader the work will then be both a manual and a guide.

A SYSTEM OF PSYCHOLOGY. By DANIEL GREENLEAF THOMPSON. In two volumes. Vol. I, 613 pages; Vol. II, 589 pages. London: Longmans, Green & Co. Price, 30*s*.

THE unobtrusive issue of this comprehensive work by an American writer will be a surprise to many. We confess to having been somewhat stunned at receiving and looking it over, and not more by its formidable proportions than by the evidences of scholarship, and mastery of the subject displayed in every page we examined. It is undoubtedly the most important contribution to psychological science that any American has yet produced; nor is there any foreign work, with which we are acquainted, that contains so exhaustive, so instructive, and well-presented a digest of the subject as this.

The work is written mainly from the point of view of an expositor. It is the object of the author to put his readers in possession of the present state of knowledge on a broad range of psychological subjects; but, while he makes no claims to any considerable discoveries, his pages betray many intimations of independent and original thought. The work is written throughout in the true spirit of science, which aims only at the establishment of truth, and in its philosophy it of course represents the latest school of psychological doctrine as it has been developed by English thinkers. In a brief preliminary note the author thus explains his relation to the minds that have mainly influenced his course of study. He says: "Besides the little I myself may have contributed, the reader is indebted for whatever science there is in this book chiefly to four other minds: to Julius H. Seelye, the personal teacher of my youth, who showed me that philosophy is possible and necessary for human welfare, and who inspired me with zeal for philosophizing; to John Stuart Mill, the ever-influencing though unseen friend of boyhood, youth, and manhood, who with the first named taught me to love truth above all things else; to Herbert Spencer and Alexander Bain, who with the second of the four have shown me the paths of true knowledge in the department of psychology."

As may be inferred from this statement, and as amply justified by an examination of it, Mr. Thompson's treatise is a systematic and symmetrical presentation of the most modern and authoritative system of psychology in which the views of Mill, Spencer, and Bain are reproduced in a connected and unified form so as to be more available for general students than in the elaborated works of those eminent authors. The task was a formidable one, but it has been thoroughly and successfully executed. The author is not a recluse professor who has been shut up in his library to spin a speculative system of his own, but he is a working lawyer, and a practical man capable of making a valuable and useful book for the public. We have been struck by the thoroughly popular nature of the exposition. The author has evidently been well trained in the important art of plain, direct, and effective statement. He is neither burdened with his learning nor the victim of its technicalities, but expresses himself with the ease and freedom of one who is master alike of his theme and the resources of skillful explanatory presentation. These characteristics adapt the treatise to popular wants, and will give it especial claims upon that large class of American readers who have neither time nor taste to conquer the formidable books on philosophy and psychology, the contents of which are here reduced to more available and attractive form.

The work, however, is large, and the field it covers is so extensive that it will be quite impossible to attempt here any representation of its general plan, any intimation of its distinctive doctrines, or any summary of the numerous problems it deals with.

But while the work is an honor to American scholarship, and the intrepid enterprise of an individual American thinker, we regret to say that it does no honor to American publishing. There is a London imprint upon its title-page, from which we may fairly infer that American publishers decline to undertake the work. Our pub-

lishing enterprise seems not to be up to the requirements of home authorship. And then the meanness of the American commercial system comes in to aggravate the difficulty. If a writer produces a work of great value for American circulation, he is driven abroad to have it printed, and then our enlightened Government forbids its entrance into the country until every copy has paid a tax, which heightens the cost and virtually embargoes its circulation.

The dedication of Mr. Thompson's book is especially interesting as a happy tribute to one of the greatest scientific minds which this country has ever produced. It reads as follows: "These volumes are inscribed by a kinsman of a later generation to the illustrious memory of Sir Benjamin Thompson, Count Rumford, a philosopher, statesman, and benefactor of mankind, a great prophet, who, while living, was not without honor save in his own country, and upon whom dead that praise justly due to a merit almost unrivaled among American men of science has been but tardily and incompletely bestowed, both by his own family and his countrymen at large."

THE REALITY OF RELIGION. By HENRY J. VAN DYKE, Jr., D.D. New York: Charles Scribner's Sons. Pp. 146. Price, $1.

THE contents of this book are neither so broad as its title, nor are they of the character which would be indicated by it. Religion is a very comprehensive term, of which all systems of religion must be regarded as but partial modifications. "The Reality of Religion," therefore, should involve an inquiry into the element of validity or truthfulness that is common to all religions. But Dr. Van Dyke enters into no such investigation. His book is an ardent pietistic defense of the importance of Christian theology. As a series of vivid and fervid appeals to poor sinners to awake and flee from the wrath to come, it will be appreciated by many, but it will not give much help to those who are grappling with the urgent religious problems of the times. When Dr. Van Dyke says of the dogmas of theology, "They are certainly as important as the dogmas of science," we hesitate, and should be better satisfied if he had indicated in what sense "important"; but, when he says of questions of ritual, "They are at least of equal consequence with the questions of social order," we have no hesitation in saying that he is entirely mistaken.

THOMAS CARLYLE: A HISTORY OF HIS LIFE IN LONDON, 1834–1881. By JAMES A. FROUDE, M. A. Two volumes in one. New York: Charles Scribner's Sons. Pp. 392 and 417. Price, $1.50.

MR. FROUDE'S method of portraying the Carlyles has become widely known from his previous volumes. To quote from the present work, "In representing Carlyle's thoughts on men and things, I have confined myself as much as possible to his own words in his journals and letters." These characteristic impressions of John Mill, Landor, Dickens, Tennyson, and other celebrated writers and their works, abound in the letters herein presented. The story of the first three years is a record of discouragement and pecuniary anxiety. Better times began with Carlyle's appearance on the lecture platform in 1837. An interesting item for a history of Yankee "book-pirates" is that, within the next two years, Carlyle received a hundred and fifty pounds from the United States as royalty on his "French Revolution," when "not a penny had been realized in England" by the author, although the receipts of the booksellers had been over a thousand pounds. Carlyle often bewailed his own choice of occupation, and his advice, when consulted by young men, was of the following tenor: "Literature, as a profession, is what I would counsel no faithful man to be concerned with, except when absolutely forced into it, under penalty, as it were, of death. The pursuit of culture, too, is in the highest degree recommendable to every human soul, and may be successfully achieved in almost any honest employment that has wages paid for it." Mr. Froude says of his first meeting with Carlyle, when the latter was fifty-four years old: "I did not admire him the less because he treated me—I can not say unkindly, but shortly and sternly. I saw then what I saw ever after—that no one need look for conventional politeness from Carlyle—he would hear the exact truth from him, and nothing else." An occasional letter by Mrs. Carlyle appears in this work; especially interesting is her written report on the domestic finances, headed "Budget of a *Femme In-*

comprise." In commenting upon the incident of the budget, the biographer says, "Both he and she were noble and generous, but his was the soft heart, and hers the stern one." The letters and extracts from Carlyle's journal concern his literary work, health, visitors, journeys to Scotland and also on the Continent, his religious belief, public policy, etc., etc. His letters to his wife are warmly affectionate, and the entry in his journal relating to her death is wonderfully tender. The criticisms on the "First Forty Years," and the "Letters and Memorials" were apparently the occasion of the introduction to this work, giving Mr. Froude's view of his duty as Carlyle's chosen biographer, with a detailed account of the manner in which the material was put in his possession, and the directions given him in regard to its publication.

WOMEN, PLUMBERS, AND DOCTORS; OR, HOUSEHOLD SANITATION. By Mrs. H. M. PLUNKETT. New York: D. Appleton & Co. Pp. 248. Price, $1.25.

THE author of this book is one of those who believe that woman's sphere should be extended; but the extension which she herein advocates is in the line of the usual duties performed by the mistress of the home. She sees no knowledge more befitting woman, no activity more worthy of her abilities, than that which serves to protect the family from disease and untimely death. After a few pages on sanitation in general, Mrs. Plunkett describes the dangers which lurk in wet house-sites and inadequate foundations, and then proceeds with the arrangement of the house for securing sufficient warmth, ventilation, and sunshine. The next chapter deals with lighting, and contains many facts in relation to dangerous burning-oils that every housewife should thoroughly know. Various ways in which water may become unwholesome are told, with directions for tests and measures of protection. The requirements of a good system of plumbing are stated, examples of defective work are given, and some explanation of the nature of sewer-gas and disease-germs is added. As many eminent physicians have declared that cholera will certainly come to America in 1885, a memorandum of the New York State Board of Health relating to the prevention of the disease has been introduced, together with directions for home treatment, including recipes for medicines. These directions are quoted from Rev. Dr. Cyrus Hamlin, who has treated hundreds of cases in the four epidemics which he has seen in Constantinople. The necessity of enforcing public sanitation is urged, both on charitable grounds and because our neighbor's carelessness may often make our own precautions unavailing. The volume contains fifty cuts, showing unsanitary conditions in Washington and New York houses, and elsewhere; elaborate plumbing in the houses of S. J. Tilden and W. K. Vanderbilt; the filtration of water through earth, sewage fungi, etc. The writer has kept house both in the country and the city, and writes with knowledge of the conditions in both locations. The command of the subject which she has gained is a sufficient contradiction of any notion that preventive medicine is too difficult for woman's comprehension. The book, though aiming especially to interest women, is addressed to all readers who desire a popular and practical presentation of this important subject; quotations from the writings of able physicians and sanitarians have been freely used, and evidently care has been taken to make a useful and reliable book.

THE AMERICAN PSYCHOLOGICAL JOURNAL. Quarterly. Volume I. Edited by JOSEPH PARRISH, M. D. Philadelphia: P. Blakiston, Son & Co. $2 a year.

THIS magazine is issued by the National Association for the Protection of the Insane and Prevention of Insanity, and its scope is indicated by the name of the association. The first volume contained articles on both the medical and legal aspects of insanity; W. W. Godding, M. D., contributed a series of papers entitled "Our Insane Neighbor: his Rights and Ours"; T. D. Crothers, M. D., discussed some phases of insanity as related to inebriety; and many letters were published describing the treatment employed in various asylums, the lunacy laws of several States, and the courses of study on mental diseases provided in prominent medical colleges. A few of the other articles are "The Rights of the Insane, and their Enforcement"; "Are Suicides Lunatics?" "Employment as a Remedy for Insanity"; and "The Prevention of Insanity."

TENANTS OF AN OLD FARM. By HENRY C. McCOOK, D. D. Illustrated from Nature. New York: Fords, Howard & Hulbert. Pp. 456. Price, $2.50.

AT the solicitation of friends, the author has adopted a narrative form for these sketches of insect-life, and has introduced two characters, an uneducated woman servant and an old colored man, who are well versed in the superstitions concerning insects which are current among the ignorant. The book contains many original observations, especially upon the author's specialties, ants and spiders, and aims throughout to express the latest and best results of scientific research. The one hundred and forty illustrations have been prepared expressly for the work, and many of them are comical adaptations by Mr. Dan Beard. Mechanically, the volume is a handsome one, but contains a few typographical errors.

THE WAY OUT. Suggestions for Social Reform. By CHARLES J. BELLAMY, author of "The Breton Mills." A Novel. New York: G. P. Putnam's Sons. Pp. 191.

HAVING written his novel, Mr. Bellamy proceeds to the trivial task of solving all the problems of modern social life, by promulgating a grand policy of reform which shall prove to be "The Way Out" for all people who find themselves hemmed in by limitations of any sort, and especially the limitations of poverty. His case may be thus summed up: "This is a government by the people who are essentially omnipotent, and can do what they like. The instrument for cutting their way out of all their terrible poverty and misery is the ballot. There are immense accumulations of property, and what is wanted is redistribution. The greatest happiness would be secured by dividing up. The politicians who have got the most ballots are the parties to do this. What is needed is greatly to enlarge the sphere of government in the way of collecting and scattering money. There are abundant precedents for this, as may be readily shown." The author says:

> Government, both national and State, by innumerable acts of legislation, has established precedents, if we seek for justification of our theory, or to speak, I think, more correctly, prove that our theory of the functions of republican government has already been practically accepted, although not carried to its logical sequence. Government already interferes to repair the banks of navigable rivers, to improve harbors, to subsidize steamships and railroads, with a view to the ultimate good they may do the nation. The same national Government fits out expeditions of exploration, and makes costly experiments in agriculture and science for the benefit of the people. The State governments have gone much further. They have loaned money to railroads and canals expected to redound to the benefit of the people, provided large sums for education rendered compulsory, and for the care of the poor, and filled in marsh-lands. County, city, and town governments have carried the theory even further. These last-mentioned governments make free bridges and highways which they care for, establish free libraries and reading-rooms, spend the public money each successive year in some new way, even to appropriating the same for the observance of memorial days, or the celebration of Fourth of July. It certainly seems as if the principle must be acknowledged, after such numerous and varied illustrations, that it is the province of government to make a constant care of the material interests and development of the country, as well as the education and happiness of the people.

In the carrying out of this grand programme the politicians who have got the most votes should regulate all profits, cut down the hours of labor, and, incidentally, take possession of all the land, because, "for the greatest good of the greatest number," "there should be no individual property in land." Then will be found "The Way Out" of "society as now organized" into "the era of plenty."

Like the author's former novel, "The Way Out" is a work of the imagination: the author seems to be concerned about no other laws of the social state than those made by the politicians; and as for political economists they are merely "apologists for an iniquitous society."

THE PHILOSOPHY OF A FUTURE STATE: A BRIEF DEMONSTRATION OF THE UNTENABILITY OF CURRENT SPECULATIONS. By C. DAVIS ENGLISH. Philadelphia: Edward Stern & Co. Pp. 16. Price, 10 cents.

IT has been long agreed that science can not demonstrate the doctrine of a future life or the immortality of the soul; but the writer of this pamphlet seems to be of the opinion that the untenability of current beliefs and speculations upon the subject can be demonstrated. Holding, furthermore, that truth is important, and that truth upon this subject is supremely important, he prints

his views, which have, at least, the rare merit of being very brief. So wide is the range of this discussion, and so many big books have been written upon it, and so diverse are the theories maintained about it, that it was certainly no small exploit to put "The Philosophy of a Future State" in sixteen pages of large and readable type, but our author does not pretend to exhaust the subject. The argument is predominantly psychological, and, if not altogether original, is, at any rate, ingenious.

ELEMENTARY TEXT-BOOK ON PHYSICS. By Professor WILLIAM A. ANTHONY and Professor CYRUS F. BRACKETT. New York: John Wiley & Sons. Pp. 246. Price, $1.50.

IN the Introduction, the place of physics among the natural sciences is defined, its methods are stated, and the operation of measuring together with certain measuring instruments, are described. The section on mechanics includes, under "Mechanics of Fluids," the subject called hydraulics in the old books. Heat is treated chiefly in relation to mechanics. A second volume is to follow, treating of electricity and magnetism, acoustics and optics. By this arrangement the connection between light and sound, as being results of vibratory motions, is more emphasized than the connection between light and heat, and the laws of radiation are not presented in the chapters on heat. The book has been prepared for college classes, and is one which students can work hard over. It attacks the subject from the mathematical side, and requires no laboratory work. The knowledge of mathematics which it presumes includes plane trigonometry.

YOUNG FOLKS' IDEAS. By the author of "Young Folks' Whys and Wherefores." Illustrated. Philadelphia: J. B. Lippincott & Co. Pp. 243. Price, $2.

THIS book contains much scientific and technical information, ranging from bread-making and mining to the nature of money and the law of wills, joined by a thin thread of story. Children who care only for stories will not find it hard to skip the useful knowledge, but in following the narrative they will meet with a great many long words, and will have their attention drawn to the vicissitudes of Wall Street, and to that occupation known as "waiting for dead men's shoes." There are good stories which give considerable scientific information, and there are scientific books which are as interesting as any story, but this book belongs to neither class.

AN APPEAL TO CÆSAR. By ALBION W. TOURGEE. New York: Fords, Howard, & Hulbert. Pp. 422. Price, $1.

THIS is a warm plea for national education of the South. Its points are supported by vigorous arguments, and re-enforced with telling statistics and diagrammatical illustrations. The author begins by attempting to show that the difference in the structure of Northern and Southern society is fundamental—not a merely temporary affair to be wiped out in a few years after the war—but a matter which lay away back of the war, and was its cause; and that under the most favorable circumstances its removal must be the work of a very long time. The difficulty has not been simplified but rather complicated by emancipation, which has brought the two elements of black and white into irrepressible rivalry. This rivalry will not diminish, but will grow with the increase of the colored element, which has been going on, and will continue to go on, with amazing rapidity, while the growth of the white population will be stationary or retrograde. On this matter, while regarding the subject from an opposite point, and with an opposite bias from those of Professor Gilliam (Northern as opposed to Southern), the author quotes approvingly that gentleman's assertion in "The Popular Science Monthly" for February, 1883, that a fusion of the two races is impossible, saying that his conclusion is indisputable "during any period with regard to which speculation may be properly and reasonably extended. Certain it is that the influences now existent will render his words as true a hundred years from now as they are to-day. What change may possibly be wrought in the tone and sentiment of generations more remote and under circumstances which can not be foreseen, it is, of course, impossible to estimate. . . . We are compelled to indorse his views in this respect almost without the least modification";

and "it is not necessary that the conclusions of Professor Gilliam, in regard to the future of the African race, should be accepted as specifically true. These prognostications do not need to be expressly fulfilled in order to convince any thoughtful mind that the problem of the African race in the United States, instead of being a question that concerns the past alone, is really the most vital and important of all the questions that can possibly occupy the national attention for the present and the future." Judge Tourgee notices the various propositions that have been made of means to meet the evils threatened by this condition of things, and dismisses as impractical and ineffective, all except that of education—of whites and blacks alike—with its liberalizing effects in removing prejudice and promoting culture. He indicates the General Government as the most competent agent for performing the educational work; and his object in publishing this book is to urge that the powers of the Government be turned to this purpose. To make his idea more plain, he sketches a plan under which the administration of the trust shall be confided to a single officer, who shall deal directly with the teachers. The great importance of the subject is obvious. Judge Tourgee's ardent presentment of the case deserves the attention of every citizen.

FICHTE'S SCIENCE OF KNOWLEDGE. By CHARLES C. EVERETT, D. D., Bussey Professor of Theology in Harvard University. Chicago: S. C. Griggs & Co. Pp. 287. Price, $1.25.

THIS little book, the third of their series of German philosophical classics which the publishers have so far issued, is not a translation, but is an exposition of Fichte's views as presented in his "Grundlage der gesammten Wissenschaftslehre." References are made also to his other writings, in order to show the relation of this work to his whole system. The first chapter gives such information about his life as is deemed helpful in comprehending his philosophy, his relation to Kant is next pointed out, and then the several main points of his philosophy are taken up. Professor Everett closes with a criticism of Fichte, and a comparison of him with Schopenhauer and with Hegel.

PUBLICATIONS RECEIVED.

The Legal Control of Medical Practice by a State Examination. By John B. Roberts, M. D. Philadelphia. Pp. 4.

Modern Railway Facilities. By W. B. Le Van. Philadelphia. Pp. 8.

Relation between the Electromotive Force of a Daniell Cell and the Strength of the Zinc Sulphate Solution. By H. S. Carhart. Pp. 4.

A Method of measuring the Absolute Sensitiveness of Photographic Dry Plates. By William H. Pickering. Pp. 4.

The Educational Influence of the Farm. By William H. Brewer. Pp. 32.

Crossing the Pasture, an Etching. By J. A. S. Monk. New York: Cassell & Co., Limited.

Report of American Association Committee on Indexing Chemical Literature. Pp. 8.

Lake Mœris and the Pyramids. By Cope Whitehouse. Pp. 4.

"The Platonist." Edited by Thomas M. Johnson. July, 1884. Orange, N. J. Pp. 16.

Bulletin of the New England Meteorological Society, November, 1884. Pp. 7.

Modern Languages as a College Discipline. By A. M. Elliott. Johns Hopkins University. Pp. 7.

Charts of Relative Storm Frequency for a Portion of the Northern Hemisphere. By John P. Finley. Washington City: Signal-Office. Thirteen charts.

Dominion of Canada. Telegraph and Signal Service Maps. Sir Hector Langevin, Minister of Public Works. Six Sections.

A Combined Visual and Astigmatic Test-Card. By Dr. William S. Little. Philadelphia. Pp. 8.

A Protestant converted to Catholicity by her Bible and Prayer-Book. By Mrs. Fanny Maria Pittar. Buffalo, N. Y.: Catholic Publication Company. Pp. 225.

Measurement of the Force of Gravity at Naba and Kagoshima. By S. Sakai and E. Yamaguchi. Tokio, Japan: Tokio Daigaku. Pp. 22.

Corcoran School of Arts, Columbian University, Washington. Address of Hon. J. W. Powell, LL. D. Pp. 20.

Notes on Ingersoll. By Rev. A. Lambert. Buffalo, N. Y.: Catholic Publication Company. Pp. 203. 25 cents.

List of the Ores and Minerals of Industrial Importance occurring in Alabama. By Eugene A. Smith, State Geologist. Pp. 11.

Dearborn Observatory, Chicago. Annual Report of the Director. Pp. 14.

Transactions of the Vassar Brothers' Institute, and its Scientific Section. Poughkeepsie, N. Y., 1883–'84. Pp. 166.

Land Laws of Mining Districts. By Charles Howard Shinn. Baltimore: S. Murray. Pp. 90.

"Babyhood." Vol. I, No. 1. December, 1884. Monthly. Pp. 32. 15 cents a number; $1.50 a year.

New York Association for Improving the Condition of the Poor. Report for 1884. Pp. 61.

"The Sun." Bi-monthly. Vol. I, No. 1. January and February, 1885. Kansas City, Mo.: C. T. Fowler. Pp. 28. 20 cents a number; $1 a year.

Baltimore Dispensary for Nervous Diseases. Report for 1883. Pp. 16.

The Rational Treatment of Chorea. By John Van Bibber. Baltimore. Pp. 8.

Notes on the Opium-Habit. By Asa P. Meylert, M. D. New York: G. P. Putnam's Sons. Pp. 47.

The Extinct Mammalia of the Gulf of Mexico, and other Paleontological Papers; Synopsis of the Species of Oreodontidæ, etc. By Professor E. D. Cope. Philadelphia: A. E. Foote. Pp. 48 and 88. With Plates.

Degeneration the Law of Disease. By L. A. Merriam, M. D. Omaha, Neb.

"The Foreign Eclectic." Part I, French; Part II, German. Pp. 32, each part; monthly. Philadelphia: "Foreign Eclectic Company." 25 cents a part, $2.50 a year for single part, $4 for both parts.

Monsignor Capel's Rejoinder to the Reply of the Rev. J. H. Hopkins, D. D. New York and Cincinnati: F. Pustet & Co. Pp. 74. 25 cents.

Progress in Education. By Mrs. H. F. Wilson. Mobile, Ala. Pp. 12.

What we know of Cholera, etc. By Frank H. Hamilton, M. D. Pp. 27.

A Spectro-Photometric Study of Pigments. By Edward L. Nichols, Ph. D. Pp. 7.

Osteology of Numenius Longirostris. By Dr. R. W. Shufeldt, U. S. Army. Pp. 32, with Plates.

Biographical Notice of Sir William Siemens. By George W. Maynard. Pp. 16.

Hampton Normal and Agricultural Institute. Treasurer's Report for 1884. Pp. 57.

Progress of Chemistry in 1883. By Professor H. Carrington Bolton. Washington: Government Printing-Office. Pp. 31.

Addenda to the Bibliography of Hyper-Space and Non-Euclidean Geometry. By G. B. Halstead. Pp. 6.

Simple and Uniform Method of obtaining Taylor's, Cayley's, and Lagrange's Series. By J. C. Glashan. Ottawa, Canada. Pp. 15.

Allan Dare and Robert le Diable. By Admiral Porter. In Nine Parts. New York: D. Appleton & Co. Pp. about 96. 25 cents each part.

Thermometer Exposure. By H. M. Paul. Detroit, Mich.: W. H. Burr & Co. Pp. 8.

Proposed Plan of a Sewerage System, etc., in Providence, R. I. By Samuel M. Gray. City Document. Pp. 146, with Plates.

Diccionario Tecnológico (Technological Dictionary), English-Spanish. By Nestor Ponce de Leon. No. 9. New York: N. Ponce de Leon. Pp. 64. Price 50 cents.

Bulletin de la Société Belge d'Électriciens (Bulletin of the Belgian Society of Electricians), Nos. 1, 2, 3. Brussels: C. Ed. Père. Pp. 131.

Contributions to the Tertiary Geology and Paleontology of the United States. By Angelo Heilprin. Philadelphia: The author. Pp. 117, with Map.

T. Lucreti Cari de Rerum Natura. With Introduction and Notes by Francis W. Kelsey. Boston: John Allyn. Pp. 385. $1.75.

Elements of Chemistry. By Professor Sydney A. Norton. Cincinnati and New York: Van Antwerp, Bragg & Co. Pp. 504.

Prehistoric America. By the Marquis de Nadaillac. Translated by N. D'Anvers. New York: G. P. Putnam's Sons. Pp. 566. $5.

"Van Nostrand's Eclectic Engineering Magazine." Vol. XXXI, pp. 524.

Book-keeping by Single and Double Entry. By a Book-keeper. New York: D. Appleton & Co. Pp. 100.

A Text-Book of Hygiene. By George H. Robé, M. D. Baltimore: Thomas Evans. Pp. 324.

The Ornithologist and Oölogist. Vol. IX, 1884. Pawtucket, R. I.: Frank B. Webster. Pp. 152.

Correspondence and Diaries of John Wilson Croker, F. R. S. Edited by Louis J. Jennings. Two volumes. New York: Charles Scribner's Sons. Pp. 384 and 372, with Portrait. Price $5.

In the Lena Delta. By George W. Melville, U. S. N. Boston: Houghton, Mifflin & Co. Pp. 497, with Maps and Illustrations. $2.50.

United States Commission of Fish and Fisheries Report, 1882. Washington: Government Printing-Office. Pp. 1101, with Plates.

Bureau of Ethnology, Second Annual Report, 1880–'81. By J. W. Powell, Director. Washington: Government Printing-Office. Pp. 477, with Plates.

Basic Pathology and Specific Treatment of Diphtheria, etc. By George J. Ziegler, M. D. Philadelphia: G. J. Ziegler, M. D. Pp. 225. $2.

Science in Song. By William C. Richards. Boston: Lee & Shepard; New York: C. T. Dillingham. Pp. 131.

The Human Body. By H. Newell Martin and Henry Cary Martin. New York: Henry Holt & Co. Pp. 261. 90 cents.

Representative British Orations, with Introduction and Explanatory Notes. By Charles Kendall Adams. New York: G. P. Putnam's Sons. Three volumes. Pp. 318, 308, 376. $3.75.

POPULAR MISCELLANY.

The Loss of the Lapham Collection.—One of the most serious losses in the recent fire at the Wisconsin State University was the scientific collection made by Dr. I. A. Lapham, and purchased after his death by the State. It consisted of a cabinet containing fossils, minerals, shells, meteorites, and Indian antiquities, 10,000 specimens in all, besides duplicates for exchange; an herbarium of 24,000 specimens, belonging to 8,000 species; and a library of about 1,500 books, pamphlets, and maps. Among the books were many rare volumes. The geological specimens included a large number of fossils peculiar to American formations, and a full series of rocks and fossils illustrating in perfect order and with perfect clearness the geology of Wisconsin. The herbarium embraced the whole range of the vegetable kingdom, with a similar treatment for all examples from the highest to the lowest. Many of the specimens were obtained by exchange from the most eminent botanists in America, England, France, and Germany.

Flowering Plants as Ozone-Generators.—Dr. J. M. Anders has published, in the "American Naturalist," descriptions of experiments he has made in the relations of plant-growth with the generation of ozone. Among the conclusions he has reached are, that the leaves have nothing to do with the production, but that the function resides with the flower; that it lies predominantly in odorous flowers, inodorous flowers being poor generators; and that sunlight, or at least good diffused light, is essential to the production. Hence, it is inferred, during fair weather all flowering vegetation is con-

tributing ozone to the atmosphere; and, as the plants blossom in succession through the season, this source of supply is in constant operation. An interesting phase of the subject is the application of the results of the observations to the question whether plants should be cultivated in living-rooms. As a rule, ozone is not detectable in rooms, because it is constantly decomposed in oxidizing the organic matter that is always present there. But, as flowering plants generate ozone in-doors during clear weather, it can not be doubted that a living-room well stocked with such plants would give off sufficient to be of hygienic value. Important advantages may also be derived from the presence of foliage plants, even though they are incapable of producing ozone, for, if properly taken care of, they will contribute essentially to the maintenance of a hygienic degree of humidity in the atmosphere of the apartment.

The Canker-Worm.—According to Professor Riley's pamphlet on the subject, there are two worms called the canker-worm, both destructive to apple, elm, and maple trees, and much alike. One is called the spring canker-worm, because the moths come out of the ground in the spring; the other, the fall canker-worm. The moths crawl up the tree and deposit their eggs upon the buds, where the larvæ, on being hatched out, begin at once to feed upon the tender leaves. The preventives against their appearance depend largely upon the fact that the female moths are wingless, and can only reach the tree-top by climbing up upon the bark. They consist, therefore, principally in surrounding the trunk of the tree with something in the nature of an obstacle that the worm can not climb by. The trunk may be tarred or greased, or a tin band may be tightly fastened around it. Such appliances are classified by Professor Riley into those which prevent the ascension of the moth by entangling her feet and trapping her fast, or by drowning her; and those which accomplish the same end by preventing her getting a foothold. Other remedies are to jar the trees and burn the worms in straw which has been laid at the bottom to catch them, and applying poisonous washings and dustings to the trees. The worms have parasitic foes, and hosts of industrious enemies among the birds, of which Professor Riley names more than forty species. In New York and Brooklyn they have been exterminated by the English sparrow.

The Condition of the Earth's Interior.—Dr. M. E. Wadsworth has published a review of the various hypotheses concerning the condition of the earth's interior. Physicists, reasoning from mathematical data, suppose it to be solid; but geological phenomena can not be accounted for on that supposition, and various compromises have been proposed to meet the requirements of the case, which are not necessary if it can be shown that the theory of solidity is not well founded. It is suggested that the difficulties alleged by the physicists against the theory of liquidity are of their own making. They have taken premises that no geologist would take, and have claimed to apply points proved regarding these assumed premises as proved for the whole earth. It is not believed to be as yet possible mathematically to prove anything regarding the state of the earth's interior. It is as necessary that physical and mathematical discussions of the subject "should conform to geological facts as it is that geological theories should conform to physical and mathematical laws. It is incumbent on the physicist to explain earthquake-motion, the rising and sinking of different portions of the earth's crust, volcanic phenomena, the uniformity in the composition of lavas, the structure of volcanic rocks, sedimentation, faulting, vein-formation, etc., by his theory of a solid crust." Much depends, in discussing the question of liquidity, upon the possibility of a solid body floating upon a liquid mass of the same substance, concerning which some writers hold that it must sink on account of its greater density, and thus compel solidification from the center. Experiments to test this point have given varying results, but show the possible existence of conditions under which the solid mass would float. Some elements solid are lighter than others liquid. The lighter solid crust would then rest on the denser liquid interior. The transition, moreover, from the solid to the liquid rock, is not sudden, as in the case of

water, but gradual, through every degree of viscosity; and the laws and properties of viscous liquids are different from those of water. Bodies will float on them which under like differences in gravity would sink in water. Now, "when the lighter surface material of the earth had cooled sufficiently, a crust would be formed, which, owing either to its lighter state in the hot condition, or to its scoriaceous character and the viscidity of the material beneath, would not sink." The viscidity of the material immediately under the crust would prevent it sinking, even if it should become heavier and break up; or, if it began to sink, it would be heated and expanded till it became no heavier than the liquid, and would soon reach a point when the liquid, being of different composition, had a higher specific gravity than the crust, and no further sinking could take place. We should thus expect to have formed on the earth's surface a crust which would never sink, or, if it sunk, only for a comparatively short distance, there to give rise to a solid crust floating on a denser heterogeneous liquid. Contractions and upheavals of this crust, not unlike in their effects what we sometimes see take place in ice, would explain all the volcanic and earthquake phenomena that need to be accounted for; while the assumption of a liquid interior accords better with the facts of petrography than any other that has been made. This assumption, according to Dr. Wadsworth's conception, is of "a heterogeneous, viscid, elastic, liquid interior, irregularly interlocked with and gradually passing into a lighter heterogeneous crust."

Value of School Recesses.—Hard as it is to believe, the idea of dispensing with recesses in school has gained so much currency among American teachers, that occasion has been found for bringing in a committee report against it, to the American Council of Education. The advocates of no recess claim that the adoption of their measure will promote the conservation of the health of the pupils, by preventing exposure; that it will tend to refinement by removing the opportunities for rude and boisterous play; that it will take away the opportunity for association with the vicious and consequent corruption of morals; and that it will make things easier for the teachers. The committee find in their report that the exposure to the weather during recess will not hurt, but be beneficial. It gives a change from the close, bad air of the school-room to the free air, with opportunity to relieve physical wants, and affords a means of ventilating the school-room without chilling the scholars; that the "rude and boisterous play" of recess is only a rehearsal of what is indulged in outside of the school-room, with the advantage that the teacher is present to restrain excess, and that it gives needed exercise; that moral corruption is not generated in the open practices of recess, but in secret intercourse; and that the teacher's office is not to make things easy for himself, but by every means in his power to promote the well-being of his pupils.

Experiments with Fog-Particles.—Physicists are divided respecting the mode of constitution of the minute particles of the vapor with which a portion of air becomes clouded when it is cooled and a condensation takes place. According to one view, the invisible vapor resolves itself at the moment of condensation into minute, full, liquid spherules, the aggregation of which produces rain-drops. Other persons suppose that the spherules are hollow and contain air, like soap-bubbles, and designate them as vesicles, while they point to the fact that fog-particles may be observed to rebound from water-surfaces, or from dry bodies, as soap-bubbles do; but full drops of water will do the same under some conditions. One of the strongest objections to the vesicular hypothesis is the difficulty of explaining how the vesicles are formed. It is hard to conceive that, during the vaporization of water, these films of liquid can separate from the surface and at once envelop small volumes of air, so as to form the profusion of microscopic bubbles of which the fog is composed. M. Félix Plateau succeeded, with soap and water, in dashing off thin films of liquid in such a way that a part of the film resolved itself into full drops, while another part gave rise to bubbles. MM. Georges Sire and Minary obtained, by stirring a mixture of olive-oil

and sulphuric acid, a multitude of hollow bubbles that flew around in every direction. The larger bubbles soon fell back into the mixture, but the smaller ones rose rapidly into the air. The floating bubbles developed the play of colors peculiar to their films; when they burst they seemed to set free a mixture of air and sulphurous acid. A magnifying-glass revealed little blisters on the surface of a part of the bubble, indicating a partial separation of the liquids constituting the mixture. When the larger bubbles burst, they gave rise to a local fog composed of spherical particles, which were supposed, but not known, to be hollow. Though these experiments seem to favor the vesicular theory, they do not overcome the difficulty of accounting for the previous formation of the liquid film; and the difficulty is increased when pure water is substituted for the soapy mixture.

Hard Literary Work.—Dr. Riart, a Frenchman, has published a book on hygiene for literary men, that contains some excellent precepts, which literary men will doubtless commend, think it desirable to adopt, and then go on in their old style. Some of the ways of French authors must have severely exercised the highest powers of physical as well as of mental endurance. Littré, during the thirteen years he was composing his dictionary, regulated his life so as to give the least possible time "to the current requirements of existence," and managed to prepare 415,636 pages of manuscript, besides matter for a supplement. He rose at eight o'clock, and wrote for an hour while his room was being arranged. Returning to his room, he read proof till luncheon-time; was at his desk again from one o'clock till six; and, after an hour for dinner, kept on at his work till three o'clock in the morning, or till the task allotted for the day was done, if it was not done then. Everything having been put in order, "my bed," he says, "almost touched my desk, and in a moment I was there." He slept as soundly as a man of leisure, till his regular hour for rising came. This was at his country workshop. In town, his hours were more liable to be broken into. Scribe rose every morning at five, and worked steadily till noon, when he varied his employment by gossiping at the theatres, etc., to put himself in harness later in the day. He lived to be seventy years old, and during his forty years of solid work produced 345 pieces, comprising 897 acts and wrote more than 100,000 verses. Elisée Reclus, according to the London "Spectator," has been occupied for eight years, and expects to be occupied for as much longer time, on his "Universal Geography," He produces a number of the book every week and a volume every year, and has never yet missed being up to time. He works, with a few short intervals for meals and exercise, from seven o'clock in the morning till eight in the evening, is a moderate eater, and has excellent health and capacity for sleep. "He seems to forget nothing, and is always ready to undertake anything, whether it be learning Russian in order the better to write his article on Russia, or making a journey to Syria in search of materials for his chapter on Asia Minor." It is simply method that has enabled these men to do their work so regularly; having once fixed upon a disposition of the time to which the mind and body can conform, what is necessary is to adhere to it and make it a matter of habit. The great thing is to get a good start; for, as Dr. Riart says, "morning work is both the easiest and the most profitable, and, depending as it does upon ourselves, it can be the most regular."

Przevalsky's Wild Horse.—M. Przevalsky, the Russian explorer, brought from his Thibetan expedition a specimen of a hitherto unknown species of wild horse, which has been named, after him, *Equus Przevalsky*. All the genera of the family *Equidæ* known previous to the discovery of this animal were more nearly allied to the genus of asses than of horses, which are distinguished from asses by having warts on the hind-legs as well as on the fore-legs, by their broad, rounded hoofs, and by having long tail-hairs growing from the base and from all parts of the tail, instead of the simple brush of hairs at the end of the tail of the asses. Przevalsky's wild horse appears to be intermediate between the asses and the horses. It has warts on its hind-legs and broad hoofs; but its tail-hairs begin to grow from about halfway down the tail, and not from the base. It differs from the true horse in having a

short, erect mane, with no forelock. Its general color is a whitish-gray, paler and whiter beneath, and reddish on the head. The legs are reddish to the knees, and thence blackish down to the hoofs, and very thick and strong. The head is large and heavy, and the stature of the animal is small. This horse inhabits the great Soongarian Desert, between the Altai and Thian-shan Mountains, and goes in troops of from five to fifteen mares, led by an old stallion. The animals are shy, and of keen senses. It was only possible to secure one specimen, which has been placed in a museum at St. Petersburg.

Evils of Children's Parties.—Dr. Cullimore, of London, has published a protest against children's parties in winter. His objections apply to the collection of children under seven years of age on such occasions. The "Lancet" would extend them to children under twelve. They apply principally to the general effects upon the health of the children, among which are those to which the excitement they have to endure before and after the event renders them liable, the exposure to the danger of chill, and to improper food and drink, and other influences that wear upon the organism at this most tender period of life. Besides these are injuries to the mind and nerves: "A perfect storm of excitement rages in the little brain from the moment the invitation has been received, and the affair is talked about in the nursery until after the evening. Sleep is disturbed by dreams, or, in some cases, prevented by thinking of the occasion, and afterward the excitement does not subside until days have elapsed, perhaps not before another invitation is received." The amusements of young children ought to be simple, unexciting, and free from artificiality. "Parties" are in no way necessary to the happiness of child-life.

Increase of Cancer.—If the data of the registrar-general's reports are correct, cancer is steadily increasing in England, and the rate of increase is augmenting. Thus, during the ten years 1850–1859, the increase in the number of deaths from this disease was 2,000, showing an average increase of about 200; from 1860 to 1869, the number of deaths was 80,049, and the average annual increase 248; and from 1870 to 1879, 111,301 deaths occurred, with an annual increase of 320. Dr. Charles Moore attempted to show, in a book published in 1865, that cancer thrives with good living, and that its increase was an accompaniment of the improved economical condition and vitality of the British people. It abounds where the conditions are ordinarily most favorable to health, and more among the rich than among the poor. According to a French observer, about ten per cent of the wealthy classes and seven per cent of the poorer classes are afflicted with cancer. The disease, according to Dr. Crisp, also prevails among animals, more frequently among flesh-eaters than among herb-eaters, and among domesticated than among wild animals. It is not zymotic or infectious, or conveyed in any way, nor is it transmissible, though the predisposition to it may be inherited; but it begins *de novo* in each individual whom it attacks. The only efficient remedy for it is the surgical one, and that should be applied at the earlier stages of the disease, while the affection is still local.

International Medical Investigation.—Dr. Sir William Gull presented before the recent International Medical Congress at Copenhagen a scheme for an International Collective Investigation of Disease, which is in effect an enlargement of the plan of organized research already in operation with the British Medical Association. The British organization has allotted its work among some fifty sub-committees, in which are included in all some thousand members. One of its methods of work is by the formation of life-histories and family histories of disease, the materials for which are obtained through the family physicians. If such histories could be widely and accurately recorded, the natural associations of different forms of disease in individuals and families would be made evident, and might afford suggestions as to pathological relations not now suspected. In such family histories we might also hope to have elucidated the difficulties of correlated pathologies—"why, for instance, in a numerous family whose members are living under the same conditions, one or two should become the subjects of pulmonary phthisis, one or two the

victims of rheumatism, another of epilepsy, while the others maintain a healthy equilibrium." The clinical subjects which have been selected so far by the British society are acute pneumonia, chorea, acute rheumatism, diphtheria, and inherited syphilis, and information is invited by means of memorandum-cards of inquiry. Several reports have been already gathered on these subjects. The German physicians have selected, for the single subject of their similar investigations, pulmonary phthisis, on which they solicit facts concerning the heredity of the disease, its communicability, its cure, and the transition of pneumonia into phthisis, with many minute particulars respecting family relations. The advantages expected to be derived from making the investigations international are, that it will give them more extent, and will enlist in them minds of varied capacity and habits, and diversified training.

Snail-Culture.—The taste for snails as food is growing in France. The mollusks are regularly cultivated in some of the vine-growing districts of the country, but the greater part of those with which the markets are supplied are raised in the department of Aude. Toward the end of the summer the snails are picked up and collected in small parks which are made in a corner of the garden or field, and are surrounded with an inclosure of sawdust and dry briers, which is stocked with aromatic plants. The park must be regularly visited, particularly in rainy weather, to drive in estrays. Toward the end of the fall, bunches of moss and dry leaves are scattered around, in which the snails may hide themselves after they have closed their shells. The animals are then captured, packed, and sent to market. The ancient Romans cultivated these gasteropods on a quite extensive scale. Their parks were large and surrounded by water, so that the snails could not escape, and an abundant supply of moisture should always be at hand. At fattening-time the animals were put in earthen pots pierced with holes, and rubbed on the inside with flour mixed with wine. Some of them grew to be very large. The Romans liked snails because they provoked thirst, and gave an excuse for drinking wine.

Insect-eating Men.—The insect-eaters here referred to are not occasional persons of depraved tastes, but whole nations, who consume insects on so large a scale as to raise them to a regular article of trade. Locusts are an article of food in parts of Africa, Arabia, and Persia, of such importance that the price of provisions is influenced by the quantity of the dried insects in hand. The Tuaregs of Africa esteem them highly, and a single individual will eat as many as three hundred of them—raw, roasted or stewed—at a meal. Cakes of crushed locusts are a delicacy. Boiled locusts are appreciated in Burmah. Termites and ants are the next most important food-insects. The egg-laden bodies of the females of *Atta cephalotes* are industriously collected by Indians in South America, and the taste of their roasted and salted bodies has been appreciated even by Europeans. The African negroes can hardly get enough of termites, which are eaten fried at the Cape, and in other regions are made into cakes. Roasted termites taste somewhat like marrow or sweet cream. The seventeen-year locust has been eaten in North America, and is said to have been used in soap-making. Cakes are made in Mexico with the eggs of two kinds of water-bugs. A cake made in Fezzan of insect-eggs is described as having the taste of caviare. The Romans were fond of a larva which they called *cossus*. A favorite dish is prepared in Jamaica from the larva of a beetle that lives in the trunks of palm-trees. Another wood-insect is preserved in sugar by the Chinese and Malays, and a liquor is made, with the addition of some water, from a beetle in Mexico. Caterpillars are eaten in Australia and at the Cape, at the risk of woful pains in the stomach, and even spiders, abhorred by every other race, are eaten by the Hottentots and New Caledonians, with the same liability. Worms are accepted as food by very few people. A kind of grub is collected and eaten in Brazil, a nereid worm in Samoa, and a reed-worm by the Ainos of Japan. The Australians around Port Adelaide are said to have lived exclusively on worms and mollusks, while they abhorred beef. Some persons in Naples eat a tape-worm, a parasite of the carp, fried in oil, and call it *macaroni piatti*. Sea-urchins form a quite im-

portant item in the cookery of some lands, and are popular in some of the Mediterranean districts of Europe. Vestiges of them are found among the remains of feasts in Pompeii, and a hundred thousand dozen of them are still sold in the markets of Marseilles every year. They, with holothurias, form important items in the food-consumption of China and Japan, where the people rarely see our butcher's-meat. The holothuria-fishery is carried on extensively in Japan from April to August. The "catch" is consumed fresh on the spot, or is prepared and packed for the Chinese market. Even the Medusa, which no other animal, so far as is known, will eat, is sought for by the Chinese, and used as a dried and salted meat.

Advantages of a Binary Arithmetic.—Mr. H. Farquhar has been discoursing, before the Philosophical Society of Washington, the advantages of a binary arithmetic, or an arithmetic in which the numbers are expressed in powers of two. In the best binary notation he devised, additions required only three fourths of the time taken with the ordinary figures. Had the computer practiced as many weeks with the new notation as years with the old, the difference would have been much more marked, as it was in fact when one unskilled in arithmetic, to whom the binary notation had just been taught, tried the two additions. A great gain in accuracy was also realized; and it is believed that a fair degree of skill in arithmetic, with a binary notation, could be acquired by many to whom readiness is impossible under the present system. The only practicable division of arcs and angles, and the most natural division of all things, is by continued bisections. This is shown by the ratio of value in our coins, weights, and capacity measures, and by the prevalent subdivision of lowest nominal units, as of the carpenter's inch into eighths and sixteenths, and of percentages into quarters, etc., in stock quotations. The American coinage is inconvenient in practice, because of the awkward ratio $2\frac{1}{2}$, which it introduces between several pieces; and there would be the same difficulty in a decimal system of weights and measures, should it be imposed upon us.

Omaha Children.—Miss A. C. Fletcher gave the American Association a pleasing picture of child-life among the Omaha Indians. The little one receives a sacred name, with impressive ceremonies, when it is ten days old, and is always lovingly attended by its father and mother. The cradle is a flat board, to which the child, laid on its back, is fastened, with bandages which are different for boys and for girls; and the pressure of the board against the head causes a flattening of the occiput. The child is kept on the board, with occasional intermissions, in which it is allowed to kick at will, till about the sixth month, when it is put into a hammock. The hair is solemnly cut, in styles peculiar to each gens, at three years of age, when the child may be given a new name. Home-life is made pleasant and attractive to the children with toys, games, and story-telling; and, at a proper age, suitable duties are assigned to the youth: the care of the ponies, the use of the bow and arrow, and the like, to the boys; and the care of the younger children, tilling the ground, dressing the skins, and cooking, in which the maiden must be proficient before she can be considered marriageable, to the girls. Great respect for woman prevails among the Omahas.

Chronology of the Fossil Flora.—Mr. L. F. Ward, at the American Association, reviewed what is known of the fossil flora of the globe. The two oldest known species (*Oldhamia*) have been found in the Cambrian of Ireland. Of the Lower Silurian, forty-four species are known, chiefly of marine algæ; of the Upper Silurian, thirteen; of the Devonian, one hundred and eighty-eight, among which ferns predominate; of the Permo-Carboniferous, nearly two thousand species. Cellular cryptogams of some kind lived in the Laurentian, and account for the graptolite beds found in it. The *Floridæ* (marine algæ), ferns, horse-tail, and club-moss families, begin in the Lower Silurian; the last three families had their maximum in the Carboniferous. The conifers, which reached their maximum in the Cretaceous, began in the Silurian. The cycads had their origin in the Devonian and their maximum in the Middle Jurassic. Monocotyledons began in the Lower Car-

boniferous and flourished most in the Tertiary. Dicotyledons began in the Lower Jurassic, and are enjoying their maximum in the present age. The earliest appearance of them is in the Urogonian of Kome, Greenland.

NOTES.

THE Italian Alpine Club is laboring to reafforest the mountains of the peninsula, and is having a measurable degree of success. In 1882 it had made plantations of greater or less extent, which were thriving, on the *Piano del Re*, near the sources of the Po; on Lake Como and Lago Maggiore. Plantations had been made in twenty-eight communes by twenty-one private persons, one of whom alone had set out 15,000 trees. Large plantations were laid out near Sondrio to resist the ravages of the wild mountain brooks. In the Apennines, Professor Magni, rector of the University at Bologna, had planted out 50,000 fir-trees near Spedaletto. These are only beginnings. The club is supported in its work by the people of the north, but the people in the southern part of the peninsula oppose it.

M. DE LACERDA has presented to the French Academy through M. de Quatrefages a paper relative to an organism—a fungoid—which he has found abundantly in the organs of persons who have died from yellow fever, and which his experiments have led him to regard as the active agent in the production of that disease. He fortifies his opinion by showing that several peculiarities of coloration displayed by this plant during its growth agree exactly in appearance with the vomited matters and with the color of the liver and the skin. He proposes to make experiments in cultivating the organism and in inoculations with it.

MM. HENRY, of the Paris Observatory, have discovered two narrow and parallel bands on Uranus located in a symmetrical relation to the center of the planet's disk. Between them is a bright zone probably corresponding with the equatorial region. The poles are comparatively dark, but the southern pole is lighter than the northern arc. M. Perrotin, of Nice, has been able with his equatorial to follow at intervals the movement of a spot on the planet, and has deduced from it a period of rotation of about ten hours. This agrees well with M. Flammarion's theoretical computation of the period of rotation of Uranus.

PROFESSOR LEIDY recently called the attention of the Academy of Natural Sciences of Philadelphia to the evidence of the presence of living organisms in ice. What appeared to be living worms had been observed in the sediment taken from a water-cooler. Upon melting some of the ice, Professor Leidy was surprised to find a number of worms among some flocculent sediment, consisting mainly of vegetal hairs and other *débris*, that settled from it. Besides the worms, there were also immature Anguillulas and a number of *Rotifer vulgaris*, all living. It appeared that these animals had all been contained in the ice, and had been liberated on its melting. The worms belonged to the family of *Lumbricidæ*. Dead worms and infusorians were also found.

M. BALBIANI has reported, agreeably to a commission given him, to the French Minister of Agriculture, on the best means of destroying the winter eggs of the phylloxera. The three methods in use were all found objectionable; that of rubbing the bark of the vines with steel-chain gloves, because it can only be applied to the old wood; the application of boiling water, because it is likely to be used carelessly; and that of washing the vines with a mixture of oil and coal-tar, because the mixture was too thick in cold weather to be used. M. Balbiani has tried with much success a wash of oil, naphtha, quicklime, and water; and it has the advantage of being cheap.

THE story is published, respecting the origin of balloons, that Madame Montgolfier had washed her petticoat to wear to a great festival on the next day, and hung it over a chafing-dish to dry. The hot air, swelling out the folds of the garment lifted it up, and floated it. The lady was astonished and called her husband's attention to the sight. It did not take Montgolfier long to grasp the idea of the hot-air balloon.

DR. UNNA, of Hamburg, has introduced a new medicament which he calls *ichthyol*. It is distilled from a bituminous rock of the Tyrol, the bitumen of which, it is evident from the fossils, is derived from the remains of marine fauna. Ichthyol differs from the coal-tars in its peculiar color and physical properties. It forms an emulsion in water, is partially soluble in ether and in alcohol, and wholly soluble in a mixture of the two liquids. It is very rich in sulphur, containing about ten per cent of that substance, and this makes it very useful in skin-diseases; for, while just as effective, it does not irritate the skin as do other preparations of sulphur. It also contains oxygen, carbon, hydrogen, and traces of phosphorus.

M. PERROTIN, director of the observatory at Nice, France, has been enabled by a happy accident, to make an astronomical observation of an earthquake. Being engaged at the moment of the shock in an observation of Hyperion, he observed the Saturnian satellite to make an oscillation of

some fifteen or twenty seconds to the right of his spider-line. It was really, of course, his telescope that moved under the force of a sharp earth-tremor which was duly recorded on the curves of the magnetometer.

THE French have formed a society called *Scientia*, for the cultivation of the social qualities among scientific men. Its first banquet was held on the 11th of December, in honor of the ninety-ninth birthday of M. Chevreuil, when M. Jamin, presiding, delivered an appropriate address to the hero of the hour, and M. Chevreuil replied.

CORRECTION.—For Düring read Düsing in the article entitled "Influences determining Sex," published in the January "Monthly."

OBITUARY NOTES.

ARTHUR HENNINGER, a French chemist of German birth, died October 4th, in the thirty-fifth year of his age. He studied and labored with Wurtz, and was distinguished for his experiments in the reduction of the polyatomic alcohols, and particularly of erythrite, by formic acid. One of the results of these experiments was the definition of a general method for the reduction of one alcohol to another of less atomicity. He was one of the editors of "Science et Nature."

DR. ALFRED BREHM, author of the "Thierleben," whose death was recently announced, was the son of a Thuringian ornithologist, and devoted his life to the study of all animal nature, but particularly of birds. He spent several years in the northeastern districts of Africa during his younger days, and later made scientific tours in distant lands, including Siberia, Turkistan, and Abyssinia. He was for some years Director of the Zoölogical Gardens at Hamburg.

MR. R. A. C. GODWIN-AUSTEN, F. R. S., an English geological author of well-earned fame, died November 25th. His first geological paper was published in 1835. His favorite topic of study was the changes going on in the present day, especially along the coast. His best-known paper was "On the Possible Extension of the Coal-Measures beneath the Southeastern Part of England." The Geological Society gave him its Wollaston medal in 1862.

THE death is announced of Mr. J. Buckman, formerly Professor of Geology and Botany at the Cirencester College, England.

DR. BODINUS, Director of the Zoölogical Gardens in Berlin, recently died suddenly. He was distinguished, previous to going to Berlin in 1869, in connection with the garden at Cologne.

DR. THOMAS WRIGHT, F. G. S., an English paleontologist, died November 17th. His specialty was fossil echinoderms, concerning the classification and structure of which, and their distribution in the secondary rocks, he contributed much that is important. He was President of the Geological Section of the British Association in 1875.

THE death is announced of Henri Lartigue, a French practical electrician. He was born in 1830; served for several years as Professor of Physics, Chemistry, and Natural History in the lycée at Auch, south of France; joined Leverrier at Paris in 1855 to assist him in meteorological observations; and after 1859 was associated with the railroad, telegraphic, and telephonic service, in connection with which he made some valuable inventions. In his youth he made a botanical and entomological exploration of the Pyrenees.

DR. AUGUSTUS VOELCKER, the distinguished agricultural chemist, died at Kensington, England, December 5th. He was born at Frankfort-on-the-Main, Germany, in 1823, studied at Göttingen, and became assistant to Professor Johnson, of Edinburgh, in 1849. He was Professor of Chemistry in the Royal Agricultural College at Cirencester from 1852 to 1862, when he became consulting chemist and professor in the Royal Agricultural Society of England. He contributed much to the Agricultural Society's "Journal" and ninety papers to the Royal Society, and he published books on the chemistry of food and the chemistry of manures, and lectures on agricultural chemistry.

PROFESSOR KOLBE, author of the "Lehrbuch der organischen Chemie," died November 26th. He was born in Göttingen in 1818, assumed a chair in the London Museum of Economic Geology in 1845, succeeded Bunsen at Marburg in 1851, and accepted a call to Leipsic in 1865. He edited the "Zeitschrift für praktische Chemie" from 1869. He was, shortly before his death, awarded the Davy medal of the Royal Society for his researches in the isomerism of alcohols.

PROFESSOR EUGENIO BALBI, Professor of Geography at the University of Pavia, died on the 18th of October. He was a son of the celebrated geographer Adriano Balbi, and was born in Florence in 1812.

THE death is announced of Mr. Robert Sabine, C. E., an English electrician who has done good work in connection with the applications of electricity. He was a son-in-law of Sir Charles Wheatstone.

RUSSIAN science has recently lost by death A. G. Fischer von Waldheim, President of the Moscow Natural History Society.

JEAN LOUIS ARMAND DE QUATREFAGES.